

Agrobiotechnology Application in West and Central Africa (2002 Survey outcome)

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(through a grant from the
United States Agency for International
Development [USAID])

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ISBN 978 131 195 9

Correct citation: Alhassan, W.S. 2003. Agrobiotechnology application in
West and Central Africa. IITA, Ibadan. 107 pp.

Acknowledgment

This is to express my appreciation to the le Conseil Quest et Center Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD) management for giving me the opportunity to undertake this very useful background study for biotechnology capacity support to the West and Central African subregion. The US Agency for International Development (USAID) deserves special commendation for funding the study and for its commitment to biotechnology capacity building in sub-Saharan Africa. It is hoped that this report will assist USAID and other development partners in determining the needed support for the subregion.

I am most grateful to the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria for hosting me and providing the needed guidance and general support. Mention must be made of Dr Peter Hartmann the Director-General, Dr Rodomiro Ortiz, the Acting Deputy-Director General (Research-for-Development), and Dr Robert Asiedu all of IITA for their encouragement. Dr Rodomiro Ortiz together with Drs Christian Fatokun and Ivan Inglebrecht deserve mention for the very useful comments, which improved the substance of the report. Any lapses in the report are, however, entirely mine.

The cooperation of the NARSs of the subregion in the execution of this study was excellent. I received the fullest cooperation from each and every NARS Director-General and respective Directors of the focal government ministries for Scientific Research and the Environment. It is hoped that this spirit of cooperation will be carried into a project implementation phase should a project emerge out of this report.

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October 2002

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Summary

In recognition of the potential of biotechnology to solve sub-Saharan Africa's growing food problems, a study was undertaken in the year 2000 under the sponsorship of the International Institute of Tropical Agriculture (IITA) (Alhassan 2001) to identify the weaknesses, strengths, and opportunities for biotechnology application for agriculture in selected countries in West and Central Africa. The countries surveyed were Cameroon, Côte d'Ivoire, Ghana, Nigeria, and Senegal. The study revealed the general weak capacity of the national agricultural research systems (NARS) for biotechnology work. Le Conseil Quest et Centre Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD) recognized the potential of biotechnology for agricultural research, but no defined focus existed.

The above study set the stage for a further, in-depth study on the capacity for agricultural biotechnology application for food security in West and Central Africa at the request of CORAF/WECARD. Funding for the study was provided by the USAID with IITA supervising and hosting the study. The countries surveyed were Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria, and Senegal.

The terms of reference for the study were:

- to make an inventory of ongoing or planned biotechnology activities
- to identify gaps and opportunities for agrobiotechnology interventions that will address issues regarding food security in the region
- to develop a framework to assist in undertaking priority setting for biotechnology research and development from a regional perspective.

The study methodology comprised consultation with key professionals and institutions in the region, literature review, and field visits.

The strengths and weaknesses of the seven countries surveyed for biotechnology are presented together with the potentials for biotechnology development.

The biotechnology research capability in Burkina Faso as this relates to trained manpower and infrastructure was low but generally better than Mali.

For Cameroon, there is considerable strength in tissue culture and a growing potential for molecular biology work. Extensive rehabilitation is required for the J.P. Johnson tissue culture laboratory. Conventional plant breeding has failed to resolve the problem with cocoyam root rot in Cameroon. Perhaps this could benefit from transformation of the plant.

The infrastructure for biotechnology in the Côte d'Ivoire is above average for the subregion except for manpower.

The biotechnology infrastructure for Ghana is weak but the manpower base is relatively strong.

Mali is easily the weakest in biotechnology capacity among the countries surveyed. There is need to consolidate infrastructure support services as Mali develops her biotechnology potential.

For Nigeria the infrastructure in tissue culture work is strong but relatively weak in molecular biotechnology infrastructure. This will however change as Nigeria develops her state of the art infrastructure in biotechnology at the SHESTCO science village in Abuja. Nigeria has in recent times exhibited great commitment to the use of biotechnology as a tool to enhance agricultural and general socioeconomic development. A biotechnology development policy has been drawn, biosafety guidelines drawn, and institutions to promote biotechnology research and development and its linkage with entrepreneurs established.

Nigeria and Mali are the two countries in the subregion targeted for USAID special support in biotechnology.

The laboratory infrastructure and manpower for agricultural biotechnology in Senegal is among the best in the subregion. The standard of biotechnology work is relatively more advanced than a number of countries in the subregion.

The level of public awareness and constraints for biotechnology are presented for the subregion. A key constraint for which there was persistent requests by the NARS was training at both researcher and technician level for both biotechnology and biosafety. Every country visited highlighted this. Next to this was laboratory infrastructure.

Less than 50% of the NGOs surveyed had a positive attitude to biotechnology products like genetically modified foods.

All countries in the subregion took varying actions on biosafety ranging from taking steps to constitute biosafety drafting committees to bringing their biosafety framework documents to the point of legislation. The most advanced in this regard are Cameroon, Côte d'Ivoire, and Nigeria. In the case of Nigeria, there is cabinet approval to begin implementing the biosafety guidelines pending legislation. Cameroon is the only country that has ratified the Catagena Protocol on biosafety. All other countries have signed the protocol and are in the process of ratification.

In proposing a regional framework for biotechnology, a cue was taken from the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) planning process since the biotechnology capacity building needs of the subregion also applied to a greater extent to the CORAF subregion. Since 1998, ASARECA had sought assistance from donors to develop the biotechnology capacity building process. The background study undertaken by CORAF in this report should accelerate the planning and management process.

The report proposes the prioritization and management of biotechnology activities in West and Central Africa within the current CORAF/WECARD network management process. The three laboratories in the subregion with quantitative trait loci (QTL) mapping capacity, namely, Centre d'Etude Régional pour l'Amélioration de l'Adaptation à la Sécheresse (CERAAS) in Senegal, the Cocoa Research Institute Ghana (CRIG) in Ghana, and Centre National de Recherche Agronomique (CNRA) in Côte d'Ivoire should be targeted for initial support to bring technologies to the level of transformation. Such laboratories alongside others that may emerge can be used as training grounds for biotechnology while solving subregional problems requiring high-level biotechnology intervention.

The biosafety framework proposed for the ASARECA subregion is generic and could be adopted by CORAF/WECARD. The biosafety review process and administration is considered from the country to the subregional, the regional (African Union), and to the global (Cartagena Protocol) levels. The trade-related aspects of the subregional biosafety framework missing in the proposal for the ASARECA region is proposed for CORAF/WECARD consideration. This considers the involvement of sanitary and phytosanitary issues in implementing subregional biosafety measures in the national and subregional context.

The current report is to be submitted for CORAF/WECARD and USAID consideration for a stakeholders' workshop to define the priorities for a regional framework of action in biotechnology and biosafety.

1

Introduction

Sub-Saharan Africa is considered one of the world's food insecure regions. The available FAO statistics indicates a worsening scenario. Africa's overall food production capacity is said to be increasing at the rate of 1.4% while its population is expanding at about 2.4% per year (FAO 2000). The continuing decline in food production will have to be reversed if massive food insecurity, poverty, and social and political instability are to be averted. Area expansion and irrigation are estimated to account for 45% of the increase expected while the remainder 55% will have to come from intensification of production from land under cultivation (Kitch et al. 2002).

Sub-Saharan Africa's food insecurity problems are largely due to drought, poor soil fertility, inappropriate farming techniques like slash and burn, postharvest losses, poor market infrastructure, poor access to farm inputs (e.g., fertilizers), conflicts, etc. The enabling political framework for agricultural and general socioeconomic development has been lacking in many African countries. These and other enabling issues are the subject matter for the newly introduced initiative—the New Partnership for African Development (NEPAD)—by the African Heads of State at their 2001 Summit in Zambia. With good governance and an enabling policy framework, the Green Revolution successfully addressed the food security problems of the developing world except Africa. Currently, however, whole Green Revolution type technologies requiring increased land, water, and fertilizer use may not be appropriate for sub-Saharan Africa due to resource limitations and population pressure. Other forms of technologies minimizing inputs while increasing yields are more appropriate. Biotechnology application is considered to be a part of the solution to our agricultural and poverty reduction problems.

Biotechnology has been defined as “any technique that uses living organisms or substances from these organisms to make or modify a product to improve plants or animals or to develop micro-organisms for specific uses” (Kitch et al. 2002). It represents a technology gradient ranging from traditional biomethods such as brewing, fermentation, baking, biological control, artificial insemination, and embryo transfer to modern biotechnology, which involves genetic engineering, highly specific or monoclonal antibody production for diagnostics, new tissue-culture methods leading to transgenics, and DNA markers to assess variation, aided-genetic analysis, or assisted-selection. Biotechnology

is multidisciplinary and finds use in health (diagnostics, vaccines, drugs, organ transplants), industry (fermentation, biodegradable plastics), the environment (cleaning of pollutants with microorganisms), and in agriculture. Some of the uses in agriculture include:

- production of large quantities of disease-free planting material through tissue culture
- DNA characterization of crops and the use of genetic markers to assist breeding that speeds up the selection process
- hybridization (crossing) of unrelated plant species for breeding that is difficult to accomplish under natural crossing such as protoplast fusion and embryo rescue
- vaccine (recombinant) production that is highly specific and effective for disease prevention
- powerful diagnostics to detect and characterize crop pests, animal diseases, or food contaminants
- Genetically modified organism (GMO) production against biotic (insect pests, diseases, weeds) and abiotic stresses (poor soil fertility and drought).

In recognition of the potential of biotechnology to solve sub-Saharan Africa's growing food problems, a recent study was undertaken under the sponsorship of the International Institute of Tropical Agriculture (IITA) (Alhassan 2001) to identify the weaknesses, strengths, and opportunities for biotechnology application for agriculture in selected countries in West and Central Africa. The countries surveyed were Cameroon, Côte d'Ivoire, Ghana, Nigeria, and Senegal. The study revealed:

- differences in capacity for biotechnology in survey countries with Senegal and Côte d'Ivoire having the most developed infrastructure
- the greatest number of trained manpower in biotechnology were in Nigeria, Senegal, Cameroon, Ghana and Côte d'Ivoire in that order
- none of the countries had biosafety laws in place in 2000 but Cameroon and Côte d'Ivoire had draft laws nearing legislation
- no intellectual property or benefit sharing laws on biological resources were enacted
- none of the countries had a national biotechnology policy formulated
- the subregional organization (Conference des Responsables Africains et Français de la Recherche Agronomique (CORAF)/West African Council for Agricultural Research and Development (WECARD) had no specific biotechnology focus
- poor government commitment to funding biotechnology research
- poor or lack of laboratory equipment or reagents
- unstable electricity supply to research stations
- poor public perception of biotechnology
- poor access to information and communication technology by scientists
- few development investors were funding biotechnology research-for-development in the subregion.

The above study set the stage for a further in-depth study on the capacity for agricultural biotechnology application for food security in West and Central Africa. The agricultural problems of the subregion have been identified and are covered broadly by CORAF/WECARD in its 2000–2004 Strategic Research Plan (CORAF/WECARD 1999).

Partners enabling this report

CORAF/WECARD

This is a subregional organization whose mission is to:

- Improve the efficiency and effectiveness of agricultural research in West and Central Africa by contributing to the construction and the consolidation of the capacities of the National Agricultural Research Systems (NARS) through cooperation between its members, development partners, regional and international organizations, the private sector, nongovernmental organizations, and users of research results.
- Consolidate the position of the West and Central African subregion within the context of the international agricultural research-for-development.

CORAF/WECARD's objectives are to:

- Promote cooperation, consultation, and information exchange between member institutions and other partners.
- Define joint subregional and regional research objectives through priority setting.
- Serve as a consultative body for research carried out by regional and international organizations operating at the subregional level.
- Develop joint research programs in order to strengthen complementary activities of CORAF/WECARD and its partners.
- Harmonize activities of the existing research networks and facilitate the creation of regional networks or other operational research units with a regional character.

The 21 member countries of CORAF/WECARD are listed in Table 1.

Table 1. CORAF/WECARD member states.

Mauritania	Togo
Mali	Benin
Cape Verde	Nigeria
Senegal	Niger
Gambia	Chad
Guinea Bissau	Cameroon
Guinea Conakry	Central African Republic
Sierra Leone	Gabon
Côte d'Ivoire	Congo
Burkina Faso	Democratic Republic of Congo
Ghana	

Ghana

CORAF/WECARD recognizes biotechnology as a tool for enhancing agricultural productivity and thus food security in West and Central Africa.

International Institute of Tropical Agriculture (IITA)

IITA aims to enhance food security, income, and well-being of resource-poor people primarily in the humid and subhumid zones of sub-Saharan Africa by conducting research (including biotechnology) and related activities to increase agricultural production, improve food systems, and sustainably manage natural resources, in partnership with national and international stakeholders. IITA conducts applied biotech research to address food and income needs, and therefore transfers in collaboration with partners, biotech products from labs to markets, serves as a platform for biotech transfer between advanced labs and NARS, and enhances selected NARS' capacity to apply and monitor biotech via comprehensive interactions and training-through-research programs.

As such IITA regards itself as a biotechnology tool user, and catalyzes—as a biotechnology method innovator—research to establish full capacity (for both products and tools) for molecular breeding and diagnostics. Therefore, IITA undertakes biotechnology research-for-development on tissue culture and micropropagation, recombinant DNA methods for diagnostics of biodiversity, and methods to detect pests and food contaminants, transgenics for transforming food crops, and genomics for marker-aided introgression and selection, particularly in banana/plantain, cassava, cowpea, maize, yams, recently in cacao, and to a very lesser extent, in soybean.

The United States Agency for International Development (USAID)

USAID is a development investor that seeks to assist countries in the subregion, among others, to develop their capacity for agricultural biotechnology to solve the region food security problem and has agreed to assist CORAF/WECARD expand the scope of the study undertaken by Alhassan (2001). The current study on agrobiotechnology in West and Central Africa is thus funded by USAID through IITA.

Terms of reference

The terms of reference for the visiting scientist to undertake this study were:

- to make an inventory of ongoing or planned biotechnology activities
- to identify gaps and opportunities for agrobiotechnology interventions that will address issues regarding food security in the region
- to develop a framework to assist in undertaking priority setting for biotechnology research and development from a regional perspective.

Expected research outputs

The expected research outputs were to:

- draw an inventory of ongoing or planned agricultural biotechnology activities
- identify opportunities for agricultural biotechnology intervention for food security in the subregion
- establish a framework to assist in biotechnology research and development priority setting and implementation from a regional perspective established.

Likewise, to:

- list priority research and those applying biotechnology tools
- determine gaps in agricultural biotechnology capacity for plant and animal production and the role of the NARS and CORAF in addressing the gaps
- define the status of biotechnology transfer to farmers and agroprocessors
- identify CORAF/WECARD overall role in the subregion and the lessons to be learned from other subregional bodies like ASARECA
- understand the position of NARS directors on agricultural biotechnology and the commitment of their countries to biotechnology issues as evidenced by the amount of support to biotechnology.

More specifically for biopolicy, this study aimed to determine the existing country biotechnology strategy and action plan, the degree of commitment to various international protocols on biosafety, and the operating biosafety framework and implementation status.

Other expected outputs were to determine the capacity and need for intellectual property rights (IPR) and impact assessment capabilities in biotechnology and general level of awareness in biotechnology issues by a crosssection of stakeholders. This study also will recommend the organization of a follow-up, subregional, agricultural, biotechnology and biosafety program or network for collaboration and harmonization of protocols, which will need a consulting stakeholder regional workshop.

Methodology

The agreed study methodology comprised consultation with key professionals and institutions in the region, literature reviews, and field visits. Target countries of the survey were Burkina Faso, Mali, and Senegal for the Sahel agroecology; Côte d'Ivoire, Ghana, and Nigeria for the coastal humid agroecology, and Cameroon for the central humid agroecology. Questionnaires drawn for the survey are presented in Appendix 1. The contact persons for the survey are listed in Appendix 2.

Findings

The extensive travel (March and May–July 2002), which characterized the countries included in the survey, translated into a 100% retrieval of questionnaires from all countries. The personal visits also facilitated discussions with key stakeholders and the corroboration of questionnaire returns with the reality on the ground. Given the extensive nature of the deliverables, the stakeholder list was expanded to include NARS, government ministries and agencies, nongovernmental organizations (NGOs) of an environmental bias or in direct contact with farmers, international agricultural research centers (IARCs) and advanced research institutes (ARIs) operating in the subregion, the media, and relevant private-sector agencies. The terms of reference and key deliverables are presented under country-specific or agency reports as well as general headings and discussions.

Country-specific findings

Burkina Faso

The umbrella organization for scientific research in Burkina Faso is the Centre national pour recherche scientifique et technologie (CNRST), which in turn is under the Ministry of Higher Education and Research. There are four broad research institutes under CNRST nearly all of which have a biotechnology mandate. The four institutes are INERA, IRSAT, IRS, and ISS. INERA (Institute of Environment and Agricultural Research) is the key institute for agricultural research and has departments dealing with plant production, animal science, natural resources, and forestry. IRSAT (Institute of Applied Science and Technology) has departments for energy, food technology, natural substances, and mechanization. IRS (Institute of Health Research) covers biomedical, public health, medicinal plants, and traditional medicine. ISS (Institute of Society and Science) and its staff work on public education, linguistics, national language, political science, and population (both migration and socioeconomic). ANVAR (Agency for Technology Transfer) organizes a two yearly science fair.

The focal CNRST institutions for the survey were INERA and the Food Technology Department of IRSAT.

INERA

INERA has the following mandate crops: cotton, rice, fruit and vegetables, legumes (groundnut, soybean, cowpea), and traditional cereals (sorghum, millet, maize). The rice, cotton, and traditional cereal programs are in Faracoba near Bobo Dioulasso. The legume program and the Central Laboratory are in Kamboinse a few kilometers from Ouagadougou. Within the Central Laboratory Complex is the Virology Laboratory. This laboratory manned by Dr Konate is one of the best equipped molecular diagnostic laboratories for plant virology in the subregion. The equipment was procured through various collaborative programs. Major funding sources were USAID, Cooperation Française, and the European Union (EU). Operational funds are procured through collaborative institutions such as the Scottish Crop Research Institute and IRD ([Institut pour recherché et développement—former ORSTOM, France]), Projet niébé pour l’Afrique (PRONAF) (cowpea) project (with IITA as implementing agency for the continent), and AIRE (Agence pour l’investissement dans la recherche à l’étrangers). Eight Francophone NARS are grouped for this fund. About 60 000 euros from this fund were earmarked for the virology lab over a period of two years. The Government of Burkina Faso only pays workers’ salaries and utilities for the laboratory. The virology laboratory thrives on good projects submitted for funding. It enjoys stable electricity and has no internet service problems. The virology laboratory has over the past 10 years trained six personnel to PhD level in collaboration with the University of Ouagadougou. The countries that have benefited from the services of the laboratory are Burkina Faso, Benin, Central African Republic, and Mali. Currently

four other professionals are under training to PhD level in various fields of plant virology including resistance mechanisms to viral diseases and studies on biopesticides (particularly to use a virus against *Helicoverpa armigera*, the cotton bollworm). Some constraints at the laboratory include the fact that it is quite old and needs to be rehabilitated. Also there is no hermetic greenhouse to prevent insect escape. Due to the extreme heat (above 40 °C at certain times of the year), the use of a glasshouse even under air conditioning has not proved successful. The electricity tariff keeps mounting and it is feared that, in the absence of projects, the tariffs cannot be maintained. Most of the relevant scientific publications are in English and not French. It is difficult for scientists to translate from French to English.

Département de technologie alimentaire (DTA)

DTA is under IRSAT. The contact person for the laboratory was Dr Brehima Diawara. Research activity in this laboratory is focused on the isolation of cultures for fermenting *pito (dolo)*, a local brew, and *dawadawa (soumbala)* a condiment. The isolated bacterium for the food condiment is *Bacillus subtilis*. Constraints facing the laboratory include the fact that there are no fermentors or bioreactors, a major constraint for a fermentation laboratory. The bacteria isolates being obtained and used in this laboratory need to be well characterized and molecular tools can facilitate this. There is therefore the need to train personnel in biotechnology to pave the way for the use of molecular techniques to characterize isolates. Currently, the laboratory uses only microscopy to characterize microorganisms. There are electricity problems as well as the absence of current journals and there are no internet facilities. A pilot plant and a new laboratory are currently under construction for DTA under a World Bank loan to the government.

Centre international de recherche/développement sur l'élevage en zone sub-humide (CIRDES)

CIRDES is the French acronym for the International Center for Research and Development on Livestock in the Sub-humid Zone. It is a CORAF/WECARD base center or center of excellence. It is located at Bobo Dioulasso. Countries collaborating with CIRDES are Burkina Faso, Benin, Côte d'Ivoire, Ghana, Togo, and Mali. CIRDES works on parasite control, animal production, and socioeconomics. Biotechnology areas of operation are diagnostics, artificial insemination, immunogenetics, and vaccine production. It carries out collaborative research with Guadeloupe in the French West Indies on cowdria (heartwater) vaccine production. There are plans to start testing the vaccine this year.

Outlook

Biotechnology research capability in Burkina Faso as this relates to trained manpower and infrastructure is low. There are no tissue laboratories for agriculture but satisfactory laboratory infrastructure for molecular biology work mainly at the plant virology laboratory and plant genetics laboratory at the University of Ouagadougou (Table 2).

Table 2. Proportion of labs in functional state in selected NARS of West and Central Africa.

Country	Functional laboratories (%)			Number of labs examined
	Tissue culture	DNA markers	Fermentation	
Burkina Faso	0	66.7	33.3	3
Cameroon	100	33.3	0	3
Côte d'Ivoire	100	100	100	1 consolidated
Ghana	46.2	30.8	15.4	13
Mali	33.3	33.3	66.7	3
Nigeria	100	28.6	42.9	7
Senegal	50	100	75	4

Training in biosafety involves exposure to the subject through focused training workshops or training received in the course of graduate or other program in a biotechnology related discipline. For any institution, a laboratory was considered nonfunctional if it lacked the biotechnology tool of interest or if it was inoperative for whatever reason. The available agricultural biotechnology manpower in Burkina Faso was the lowest among the countries surveyed (Table 3). As it is the situation with all NARS of the subregion, the number of staff trained in biosafety was minimal to absent. In the case of Burkina Faso this was zero. INERA plans to build a modern plant biotechnology laboratory at Kamboinse.

The agricultural biotechnology research activities in Burkina Faso cover molecular characterization of the common cereals of maize, millet, and sorghum as well as the molecular characterization of plant viruses and monoclonal antibodies for diagnostic research (Table 4). DTA is collaborating with the Council for Scientific and Industrial Research (CSRI)–Food Research Institute (FRI) of Ghana in food fermentation studies on *dawadawa* or *soumbala*. Animal biotechnology research carried out in collaboration with CIRDES covers DNA characterization of trypanosome and embryo transfer (Table 5). Biotechnology research activities planned for the future include tissue culture work and the isolation and molecular characterization of soil microbes.

Table 3. Available manpower for biotechnology and biosafety in NARS of West and Central Africa.

	Number of personnel						% in biosafety
	Biotechnology graduate	Tech	Biosafety graduate	Total Tech	Biotech	Bio-safety	
Burkina Faso	5	1	0	0	6	0	0
Cameroon	15	8	0	0	23	0	0
Côte d'Ivoire	10	8	1	0	18	1	5.3
Ghana	43	24	8	4	67	12	15.2
Mali	15	3	0	0	18	0	0
Nigeria	19	12	0	0	31	0	0
Senegal	47	32	4	2	79	6	7.1
Total	154	88	13	6	242	19	7.3

Table 4. Plant biotechnology research projects in Burkina Faso.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Molecular characterization	Millet, sorghum, maize, rice	DNA characterization	INERA	Crops of known genetic make-up	Planned	Government
Enzymatic characterization	Millet, downy mildew	Not applicable	INERA	Downy mildew control	Ongoing	Government
Tissue culture	potato, sweetpotato, yam, cassava, cereals (anther culture)	Tissue culture	INERA	clean planting material	Planned	Government
Molecular characterization and diagnostics	Plant viruses	NDA characterization and monoclonal antibodies	INERA	Effective control of plants virus	Ongoing	Government
Soil microbes isolation and characterization	<i>Rhizobia mycorrhizae</i>	Fermentation	INERA	Inocula as fertilizers	Planned	Government
Isolation of food fermentation cultures	<i>Soumbala, dawadawa</i> (fermented <i>Parkia</i> seeds)	Fermentation	DTA/ISAT with Ghana Food Research	Food condiment	Technology	DANIDA

Table 5. Animal biotechnology research projects in Burkina Faso.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Gene map of trypanosomes	Trypanosomiasis	DNA characterization	INERA in collaboration with CIRDES	Characterized trypanosomes for control	Ongoing	Government
Embryo transfer	Embryos for transfer in cattle	Not applicable	INERA	Enhanced reproduction in cattle	Ongoing	Government

Cameroon

Cameroon was included in the early 2000 survey (Alhassan 2001). IRAD (Institute of Agricultural Research and Development), CARBAP (Centre Africain de recherches sur bananiers et plantain), and the University of Yaounde I are the institutions doing agricultural biotechnology research in the Cameroon. Relevant IRAD departments are the Wakwa Animal Health Laboratory at Ngouandere and the JP Johnson Biotechnology Laboratory at Ekona. The University of Buea has an active biotechnology center but it currently specializes on malaria and onchocerciasis biotechnology research. It has potential to undertake postgraduate training in agricultural biotechnology in collaboration with IRAD or other agricultural institution. The Wakwa laboratory is currently working in the following areas: epidemiology of foot and mouth disease using molecular diagnostic procedures, and Newcastle disease control for rural poultry. Effective vaccine administering methods are also being investigated, but it does not involve a modern biotechnology approach. Constraints facing the Wakwa laboratory include manpower as all the trained manpower in biotechnology left the institute due to funding constraints for effective research.

Centre Africain de recherches sur bananiers et plantains (CARBAP)

CARBAP was known formerly as CRBP (Center for Research in Banana and Plantain), and is located at Njombe. The contact person is CARBAP Director Dr Kodjo Tomekpe, a plant breeder with some exposure to molecular biology. CARBAP has a tissue culture unit and a new molecular biology unit. The molecular biology unit is an addition since the last survey in 2000. The key activity currently is in the tissue culture area. The tissue culture projects are embryo rescue for banana and plantain hybrid seed and in vitro multiplication. CARBAP has a mandate from the International Network for the Improvement of Banana and Plantain (INIBAP) to multiply virus-free plants and distribute these to the West and Central Africa (WCA) subregion, somatic embryogenesis of banana and plantain, and in vitro germplasm conservation at 14–15 °C. The Molecular Biology Unit established in 2002 has two objectives: (i) molecular diagnostics for banana streak virus using polymerase chain reaction (PCR) methods and (ii) identification of new genomes using microsatellites through collaborative research with Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) at Montpellier. The training unit organized a regional course for Francophone countries on the use of molecular markers, with CIRAD providing resource staff. The course was held from 6 to 14 November 2001. CARBAP has the potential to organize such training in the future upon support from CIRAD. CARBAP is also a regional center for banana and plantain research for five countries, namely, Cameroon, Central Africa Republic, Democratic Republic of the Congo, Equatorial Guinea, and Gabon—all CORAF/WECARD member countries. Other research areas at CARBAP include mycorrhiza production and distribution. CARBAP has identified mycorrhiza against nematodes in banana. CARBAP technology transfer assists

a private company SPNP (Société des plantations de Njombe-Penja) to monitor plant diseases at a fee, small-scale farmers indirectly through tissue culture planting material sent through NARS, and provides the split-corm technique for multiplying plantain to farmers. CARBAP expressed concern about the lack of information by African scientists on what their African colleagues in related research laboratories were doing and thus proposes various biotechnology networks for tissue culture for specific crops, and mutation breeding of banana and plantain from somatic culture and molecular biology, which is considered a must for strategic work. CARBAP considers that NARS should be empowered to do their own strategic research in molecular biology because it does not share the view that this kind of research will be costly for NARS involvement.

CARBAP faces the following constraints: electricity but it has now purchased four generators for each of its four laboratories; manpower particularly trained molecular biologists; and funding because only the EU and the Government of Cameroon are providing funding that appears to be inadequate. Communication problems with regard to telephone service and Internet connectivity exist.

JP Johnson Biotechnology Laboratory

This is one of the laboratories covered extensively in the 2000 survey (Alhassan 2001). The laboratory is still under the leadership of Dr Zok Simmon. It currently devotes its entire facility for tissue culture work in root and tuber crops as per its original mandate. Projects ongoing and planned in various commodities are as indicated below by crop.

Cassava

- Tissue culture multiplication. Tissue culture derived cuttings are distributed to farmers. Farmers return for fresh tissue culture derived material once in 3 or 4 years when there is decline in plant vigor.
- Molecular diagnostics and plant improvement against root rot and poor tuber formation. Work in this area is yet to start.
- Need to conserve local accessions in vitro, but lack the laboratory facilities.

Yam

- Tissue culture multiplication. The laboratory still gets very small sized tubers from tissue culture material. It is now using mycorrhiza to increase size of tubers with encouraging results, but research has been suspended for lack of funds.
- It continues with germplasm maintenance in the field due to lack of facilities for in vitro conservation.

Cocoyam

- The root rot disease of cocoyam remains intractable despite many years of research into how to contain the disease. The disease is caused by a fungus. Currently screening for resistance to the fungus is carried out while tissue culture is used to multiply disease-free planting material. In addition, work is ongoing in:

- Field breeding for resistance to root rot.
- Mutation breeding against root rot.
- Biological control using bacteria to control the root rot fungus. The initiative will eventually require a fermenter to culture bacteria as the biological control agent.
- Multiplication through somatic embryogenesis is ongoing through collaborative work with Penn State University, USA, and Centre national de recherche agronomique (CNRA) in Côte d'Ivoire. This work is currently on hold due to the lack of reagents.

Planned cocoyam research includes crossing resistant cocoyam with commercial cultivars. There is need to do gene transfer through anther culture, ovule culture, and embryo rescue. Also they plan gene transfer by molecular means subject to the availability of a molecular biology laboratory and DNA characterization of cocoyam germplasm. The major constraint is obsolete equipment that needs refurbishment, though currently a room is being refurbished for a transfer chamber for tissue culture. Also a new autoclave has been provided by the International Atomic Energy Agency (IAEA). This laboratory that was in a deplorable state during the 2000 survey is still in a poor shape. Other constraints are finance for equipment and reagents, shortage of trained personnel, the need for a molecular biology laboratory, poor communication equipment including Internet facility, lack of journals, and electricity problems (though it has a standby generator fuel cannot be bought to run it). Also, continuous training is needed because this is currently absent. There are problems with purity of laboratory reagents.

University of Buea Biotechnology Unit

This is an active laboratory with postgraduate training in molecular biology in relation to the diagnoses and control of malaria and onchocerciasis. It has potential to undertake postgraduate training in agricultural biotechnology if funded and linked to IRAD or other agricultural institution in the country. The contact person is Prof. Vincent Titanji.

Outlook

The laboratory infrastructure and manpower base in Cameroon is comparable to or better than the situation in some of the countries surveyed (Tables 2 and 3). There is no facility for fermentation needed for the production of biopesticides. There is considerable strength in tissue culture and a growing potential for molecular biology work improving on what obtained in 2000. The JP Johnson laboratory at Ekona needs support to rehabilitate its infrastructure to incorporate aspects of molecular biology in its germplasm screening work. The intractable problem on cocoyam root rot could benefit from transformation in linkage with an advanced laboratory in the subregion like IITA or overseas. Postgraduate training to PhD level currently available for tissue culture at the University of Yaounde I and molecular biology at the University of Buea need strengthening as regional training centers in biotechnology for the Central African subregion and beyond. The ongoing and planned agricultural biotechnology projects in Cameroon are summarized in Tables 6 and 7.

Table 6. Plant biotechnology research projects in Cameroon.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Micro-propagation	Cassava,	Tissue culture	JP Johnson	Clean planting material	Transferred to farmers	Government, IPGRI, World Bank, AfDB
Micro-propagation	Cocoyam, Cocoa, root and ruber crops, non-timber forest plants	Tissue culture	University of Yaounde 1	Cleaning planting material	Transferred	CIRAD, IPGRI, Montpellier (non-timber forest product)
Root rot control	Cocoyam	Molecular markers, mutation breeding, genetic transformation	JP Johnson in collaboration with advanced laboratory	Root rot resistant cocoyam	Planned	Searching
Mass propagation	Banana, plantain	Tissue culture	CARBAP in collaboration with IPGRI	Clean plantlets	Transferred	Gatsby
Streak virus control	Banana	Molecular characterization	CARBAP	Disease-free plantlets	Planned	Searching
Germplasm characterization	Banana, plantain	Molecular characterization	CARBAP	New germplasm	Planned	EU

Table 7. Animal biotechnology research projects in Cameroon.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Foot and mouth disease Other cattle diseases	Cattle	Cell culture, DNA characterization and molecular markers	IRAD	Vaccine-recombinant	Ongoing	Wellcome Trust

Côte d'Ivoire

The laboratories in Côte d'Ivoire dealing with agricultural biotechnology were extensively reviewed in the 2000 survey (Alhassan 2001). The current study focuses on CNRA's (Centre national de recherche agronomique) Central Biotechnology Laboratory that is the predominant biotechnology laboratory in Côte d'Ivoire and one of the best equipped in the subregion. It arose out of the merger of three existing agricultural research institutes, namely, the Institut des savannes (IDESSA), The Institut des forêts (IDEFOR), and Center Ivoirien de recherche technologique (CIRT) in 1998. All the biotechnology resources in the three institutes were pooled into the Central Biotechnology Laboratory (CBL). The Head of the Central Biotechnology Laboratory is Dr A. Sangare, a molecular biologist. The Central Biotechnology Laboratory has the following divisions: physiomolecular biology, molecular biology, molecular genetics, tissue culture, and training. The Genetic Resources Unit will be developed with the assistance of the International Plant Genetic Resources Institute (IPGRI). Cold chambers are being developed for the preservation of plant genetic resources, which also includes cryopreservation.

CNRA

CNRA operates in three broad areas: (i) basic research such as gene cloning, (ii) technology transfer such as the release of improved cultivars and tissue culture materials, and (iii) training. The Central Biotechnology Laboratory (CBL) is viewed as a regional training center for biotechnology. In collaboration with the University of Abidjan, about 10 PhDs are undergoing training at the CBL. CNRA ran a training course on the Formation and utilization of genetic markers and biochemical and molecular markers for the management of rice genetic resources from 26 February to 3 March 2001. The course was sponsored by CORAF/WE CARD and CIRAD. Funding was provided by Association des universités partiellement ou entièrement de langue française (AUPELF—an Association for the support of Francophones). Participants came from Benin, Burkina Faso, Côte d'Ivoire, Mali, Senegal, and Togo. In future the Center would want to train staff from both Francophone and Anglophone countries. CNRA key research areas will include DNA characterization of African genetic resources, which is a proposal submitted to IPGRI. It covers 27 countries in sub-Saharan Africa zones (nine each for West, East, and Southern Africa, of which three plants are common to each of the nine countries in each subregion). Standardizations of DNA extraction protocols are also on the agenda.

IPGRI asked CNRA to undertake this study of developing and standardizing DNA extraction protocols for plants according to botanic classification criteria, and this ongoing project started in January 2002. Molecular markers will be included to identify tolerant plant genotypes to drought, salinity, disease, insect attack, and other stresses. Likewise, molecular genetics will assist plant breeders to determine the influence of environment and genotypes on disease resistance, which will aid in the selection of this trait. In tissue culture, the work gives priority to cocoa embryogenesis. Other plants are oil palm, banana, plantain, and yam. CNRA has had over 3000 ha tissue culture generated oil palm trees

under observation for the past eight years at its experimental station at La Me near Abidjan. The CBL of CNRA has earmarked two laboratories for regional work in biotechnology. Together both laboratories have enough bench space to accommodate 50 to 75 visiting scientists. Equipment available for this work was yet to be installed at the time of the visit in May 2002. The International Germplasm of Coconut for Africa and the Indian Ocean, a field gene bank, is located at Port Bouet in Côte d'Ivoire. It is yet to apply biotechnology techniques to its work.

Other experimental stations of CNRA dealing with agricultural biotechnology are the stations in Bouaké, which include the livestock station, and the microbiology and the cotton research units. There is no facility for livestock biotechnology work in the unit. There are plans to work with the International Livestock Research Institute (ILRI) and Centre national pour la recherche et le développement de l'élevage en zone subhumide (CIRDES) in Bobo. With ILRI, the interest is on DNA characterization of local poultry to determine genetic diversity. DNA characterization also started on cattle with CIRDES. No biotechnology work is planned on small ruminants. Successful conventional breeding on the local Djallonke sheep started in 1984 and resulted in an improved local breed for size. The genetic purity of this improved local sheep could be ascertained through the use of DNA markers for characterization. The microbiology unit successfully produced rhizobium cultures for ongoing distribution to soybean growers. The cotton research unit is interested in cotton genetic transformation because of the demand from cotton growers who have been made aware of Bt-cotton by the local Monsanto agent. Research on transgenic cotton waits for the expected biosafety legislation. There is serious concern over insect pests and their growing resistance to the common insecticides. Alternatives to pyrethroids are being sought for cotton insect pests. There are currently five to six sprays per crop. Integrated pest management (IPM) with threshold sprays is being introduced to combat the situation. Bt-cotton testing before commercial introduction is tempting given the current pest challenge. The efficacy of the imported Bt-cotton against the local strains of bollworms must be ascertained. It is hoped to use biotechnology to characterize insect populations to identify the resistant populations and their distribution. The research ongoing as well as that planned for the CNRA in Côte d'Ivoire are summarized in Table 8.

Commercialization of tissue culture-derived planting material

This is ongoing at OCAB (Organisation centre des producteurs-exportateurs d'ananas et de bananes, Abidjan, Côte d'Ivoire). This company commercializes the export of bananas and is the largest farmer union in the country. Tissue culture plantlets are imported from France or South Africa, hardened, and sold to farmers. The supply of tissue culture plantlets from France (CIRAD) started in 1999. The company hopes to produce its own tissue culture plantlets. CNRA surprisingly is not being contacted to provide the tissue culture material though it has the capacity to do so. As at the time of visit (mid-May 2002) to OCAB the cost of a hardened tissue culture plantlet to outgrowers was CFA 480 francs (about US\$ 0.70).

Table 8. Plant biotechnology research projects in Côte d'Ivoire.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Micro-propagation	Cassava, yam, pineapple, cocoa (somatic embryogenesis), oil palm	Tissue culture	CNRA with Penn State for cocoa	Clean plantlets for mass propagation	Cocoa nursery, near to release for oil palm, transferred for root and tuber crops	Government
Germplasm characterization	Cocoa	Molecular characterization	CNRA	Germplasm of known genetic make up	Nursery	Government
Harmonization of protocols	DNA extraction and characterization procedures	Molecular characterization	CNRA	Standard protocol	Ongoing	IPGRI
Germplasm characterization	Selected plant genetic resources of 27 African countries	Molecular characterization	CNRA with African NARS	Characterized African genetic resources	Planned	IPGRI
Dry tapping panel phenomenon	Rubber	Molecular markers	CNRA	Genetic basis of problem established	Ongoing	

Outlook

The infrastructure support base for biotechnology research in Côte d'Ivoire (Table 2) is above average for the subregion but more needs to be done to increase the manpower base (Table 3). The ongoing PhD training in collaboration with the University of Abidjan is to be encouraged. The space being created for subregional research collaboration in biotechnology in the subregion is a possible answer to the call for subregional cooperation in agricultural biotechnology research.

Ghana

The depth of coverage was probably greatest in Ghana since the consultant spent the most time there for the purpose of the survey. One month of the initial preparatory phase was spent in Ghana. Ghana was one of the countries covered in the 2000 survey (Alhassan 2001). The agricultural research institutes affiliated with the Council for Scientific and Industrial Research (CSIR) which were surveyed were the Crops Research Institute (CRI), the Food Research Institute (FRI), the Plant Genetic Resources Center (PGRC), the Oil Palm Research Institute (OPRI), the Coconut Research Project, the Soils Research Institute (SRI), and the Savanna Agricultural Research Institute (SARI). Outside the CSIR-based institutes, the Biotechnology and Nuclear Agricultural Research Institute (BNARI), the Cocoa Research Institute of Ghana (CRIG), the Botany Department of the University of Ghana (BD/UG), the Crop Science Department of the University of Ghana (CSD/UG), Crop Science Department of the Kwame Nkrumah University of Science and Technology (CSD/KNUST), and the Veterinary Services Department of the Ministry of Food and Agriculture (VSD/MOFA) were surveyed. Apart from information from questionnaire returns, further discussions were held with a select few to further clarify issues raised in the questionnaire returns and to provide more details.

CSIR institutes

Biotech research areas of interest at CSIR–CRI are stress breeding, improving nutritional content of crops, and DNA characterization for breeding and selection. Training of personnel is required in molecular biology and virus indexing. Ongoing projects include tissue culture of bananas, plantain and root and tuber crops as well as DNA characterization of cowpea and cassava in collaboration with other laboratories. CRI envisages future uses of biotechnology for embryo rescue work on yam and bambara groundnut, anther culture, marker-assisted breeding, and selection. Basic requirements are, therefore, training, laboratory equipment, and lab building. Other constraints are associated to staff skills in biotechnology, especially those with knowledge on molecular biology, who are not practicing their profession for lack of a lab. Such staff are likely to get “rusty” and therefore frustrated. The provision of an appropriate lab will be concomitant with training. CSIR–CRI linkage with universities for graduate training must be stressed because it appears to be underutilized. The CSIR biotechnology committee seldom meets. Likewise, nothing was heard of

the Strategic Alliance for Biotechnology Research in African Development (SABRAD) initiative, which was launched in Ghana in 2000 to help building capacity for the use of agricultural biotechnology for sustainable development in Africa. SABRAD was to be coordinated by Tuskegee University, USA. We subsequently learnt that SABRAD is yet to procure the funds to proceed with the program.

The emphasis of biotechnology work at CSIR-SRI is in soil microbiology. Inoculum production is the focus. The institute is involved with isolation, characterization, and study of the effectiveness of the isolates. It currently uses microscopy to do the characterization. Most important constraints are the serious lack of equipment (nothing for molecular biology and no fermentor), and training of scientific staff in molecular microbiology techniques, which seems to be urgently needed..

The bulk of the information concerning the OPRI-Coconut Research Project (cited below) and on the Lethal Yellowing Disease (LYD) (also known as Cape St. Paul wilt disease in Ghana) was provided by Dr S.K. Dery, the project coordinator. The project was established in 1990 to deal with the scourge of LYD of coconut. The disease is of an unknown etiology and epidemiology. It is currently the most devastating disease of coconut in Ghana and in other countries of the subregion where it is endemic. The disease surfaced in Ghana in 1932 and has wiped an estimated 5500 ha of coconut plantation in the Central and Western regions of Ghana. Coconut cultivars resistant to the disease in the Caribbean succumb when brought to Ghana. Concerted efforts to research into LYD started in 1990 with European Commission assistance under the EC-STD III grant. Under the EC-STD III, the Department for International Development (DfID) of the United Kingdom established a small molecular biology unit at the Crop Science Department of the University of Ghana to train students while researching into the disease. Currently the grant has lapsed but the French Government is assisting this institute to build a molecular biology unit in Sekondi in the Western Region of Ghana to combat LYD. Currently staff from CIRAD, who will build the molecular biology laboratory, are working with OPRI staff in the endemic regions of the country. The running cost of the laboratory when built will be met through the Agricultural Services Subsector Investment Program (AgSSIP) World Bank loan to the Government of Ghana. At the International Coconut Workshop (Mombasa, Kenya, May 2000), Ghana was designated by the Bureau for the Development of Research on Perennial Oil Crops (BUROTROP) as the Coordinator for LYD research in Africa. The areas of research recommended by the workshop include etiology, epidemiology, and transmission of LYD, vectors of LYD, diversity of LYD strains, control and containment of LYD, sources of resistance plus mechanisms of resistance, and transmission of LYD by seed or pollen. The OPRI-Coconut Project liaises closely with the Regional Coconut Germplasm Center at Port Bouet in Côte d'Ivoire for its breeding work. All 35 coconut cultivars tested in Ghana originate from this source.

CSIR institutes virtually lacking in biotechnology infrastructure, but which nevertheless are collaborating with other institutions, are the CSIR-SRI, the CSIR-SARI, and the CSIR-PGRC.

Non-CSIR institutes

The Botany Department of the University of Ghana has a modern biotechnology lab that runs a popular tissue culture training course in the subregion. The course has been running since 1998 with funding from the United Nations University Institute of Renewable Natural Resources in Africa. The course coordinator is Dr Elizabeth Acheampong. The activities of other institutions surveyed are as tabulated in Tables 9 and 10.

Outlook

The infrastructure base for agricultural biotechnology is currently weak in Ghana (Tables 2) but the manpower base (Table 3) is relatively strong. With the modest capacity, the NARS is playing a very active role in biotechnology research as evidenced by the ongoing activities summarized in Tables 9 and 10.

Mali

Like Burkina Faso, Mali is an addition to the countries surveyed in 2000 (Alhassan 2001). Most agricultural and thus agricultural biotechnology research in Mali is carried out under the Ministry of Rural Development (MRD). The relevant institutions are the IER (Institute of Rural Economy) with various programs for sorghum, nutrition, food technology, cattle, and forestry; the LCV (Central Veterinary Laboratory); and the DGRC (General Headquarters for Regulations and Control) which deals with biosafety issues. Some agricultural research is carried out under the Ministry of Education. These are the IPR/IFPRA (Rural Polytechnic Institute and Institute of Applied Research) that house the Biotechnology Laboratory at Katibougou and the LBMA (Applied Molecular Biology Laboratory) of the FAST (Faculty of Science and Technology) of the University of Mali. The author had the privilege to participate actively in a biotechnology, biosafety, and intellectual property workshop sponsored by Syngenta, Rockefeller Foundation, and USAID (4–6 June 2002). The workshop helped to define a course of action in biotechnology research and biosafety development for Mali. This timely workshop preceded the tour of Mali.

Biotechnology Laboratory at Katibougou

This laboratory was developed with funding from The International Atomic Energy Agency (IAEA). It is a well-equipped tissue culture facility. The head of the laboratory is Dr Bretaudeau, a plant breeder. Most of the work in this laboratory is in tissue culture but some ongoing mutation research uses radiation. The entire tissue culture facility is funded by the IAEA (Vienna). The laboratory is engaged in tissue culture for Irish potato planting material production for the subregion. There is a growing demand for this. The laboratory is also conducting research on anther culture in sorghum. Progress in this work is hampered by the accretion of polyphenols in sorghum that makes androgenesis difficult. The lab developed 16 sorghum cultivars from induced mutation and regular breeding, which have been registered in the national catalog and made available to farmers. The laboratory plans to start the production of tissue culture banana soon.

Table 9. Plant biotechnology research projects in Ghana.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Micro-propagation	Banana, plantain, cassava, pineapple, ginger, citrus, sheanut, cocoa, cocoyam	Tissue culture	BNARI-GAEC CSD/UG CSIR-CRI BOT/UG CSD/KNUST CRIG (cocoa and sheanut) with IITA for <i>Musa</i>	Disease free plantlets for mass propagation	Technology transfer save for sheanut (CRIG) and citrus (CSIR-CRI)	IAEA, Gatsby
Root crop germplasm characterization	Cassava, yam, cocoyam	Molecular characterization	CSD/UG in collaboration with BNARI/GAEC and PGRC	Characterized germplasm	Completed	FAO/IAEA
<i>Musa</i> spp. characterization	Banana, plantain	Molecular characterization	BNARI in collaboration with CSD/UG	Characterized germplasm	Completed	IPGRI
Rhizobium isolation and characterization	Inoculant	Fermentation	CSIR-SRI	Rhizobia inoculant	Planned	Government
DNA protocol for Lethal Yellowing Disease (LYD) phytoplasma	Coconut	Molecular markers	CSIR-OPRI with CSD/UG and NRI-UK	Phytoplasma protocol	Completed	EU STD III

.../continued

Table 9. (Cont.)

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Identification of LYD phytoplasma in putative insect vectors	Coconut	Molecular markers	CSRI-OPRI with CSD/UG	Vector identified for LYD	Ongoing	Government
Screening coconut disease tolerance and high yield	Coconut	Molecular markers	CSIR-OPRI in collaboration with IACR-Rothamsted CP-CIRAD CSD/UG	Disease tolerant and high yielding coconut varieties identified	Planned	Government
Germplasm characterization	Coconut	Molecular characterization	CSIR-OPRI in collaboration with IACR-Rothamsted, CP CIRAD and CSD/UG	Germplasm or known genetic make-up	Planned	Government
Micro-propagation	Coconut, oil palm	Tissue culture	CSIR-OPRI with CP-CIRAD and CSD/UG	Plantlets for mass propagation	Planned	Government
Biocontrol	Coconut	Fermentation and other approaches	CSIR-OPRI with CIRAD and CSD/UG	Biocontrol agents	Planned	Government

.../continued

Table 9. (Cont.)

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Diagnostic probes development	Plantain, coconut	Molecular markers	CSD/UG in collaboration with IITA and NARS	Diagnostic probes	Monoclonal serological assays developed, PCR diagnostics developed	Government
Food fermenting microbes sub-species typing	Fermented foods: maize, cassava, soybean, (dawadawa), palm wine (vinegar)	Fermentation	CSIR-FRI in collaboration with African Food Fermentation Network	Starter culture	Completed	DANIDA
Mycotoxin degradation	Aflatoxin in foods	Fermentation	CSIR-FRI	Microbial enzyme	Ongoing	EU
Characterization for disease resistance and molecular breeding	Cocoa	Molecular markers and introgression	CRIG	Disease resistant planting material	Ongoing	IAEA
DNA characterization	Maize	Molecular characterization	CSIR-SARI in collaboration with WECAMAN	Germplasm of known genetic make up	Planned	USAID

Table 10. Animal biotechnology research projects in Ghana.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Development of diagnostics	Heartwater, dermatophilosis Newcastle disease	Tissue culture (heartwater only), monoclonal antibody	VSD in collaboration with Noguchi Institute in UG	Diagnostic kit	Ongoing	Government

Laboratoire de biologie moléculaire appliqué (LBMA)

Dr Ousmane Koita is the contact person in the Applied Molecular Biology Laboratory of FAST at the University of Mali. The laboratory currently works on diseases, namely, malaria, human trypanosomiasis, and onchocerciasis. There are plans to start work in the near future on agricultural biotechnology. Currently postgraduate training is in health molecular biology, but the laboratory is willing to link with agricultural research institutes to offer training in agricultural biotechnology. FAST will open up its facilities to IER staff for work on molecular biology as well as training their staff in the field.

Central Veterinary Laboratory (LCV)

The Head of the Division of Research and Diagnosis of the Central Veterinary Laboratory (LCV) is Dr Mamadou Niang. The laboratory was built through USAID funding more than 30 years ago. The divisions are for administration and support services, vaccine production, and research and diagnostics. There are 10 specialized laboratories, which support research programs. LCV produces nine types of vaccine products mainly for ruminants. There are plans to produce poultry vaccines in the future. The collaborative partners are IER, FAO, UNDP, EU (particularly CIRAD), USAID, and IAEA. The areas of biotechnology application are PCR-based diagnostics in contagious bovine pleuropneumonia (CBPP), pestes des petits ruminants (PPR), foot and mouth disease (FMD), and rinderpest. It is planned to produce a recombinant vaccine against CBPP. Studies are ongoing to produce a vaccine against pasteurellosis in ruminants. About 20 to 25 million doses of the different types of vaccines were planned for 2002 for distribution in the subregion. The requirements of LCV in the order of priority are training, equipment, and building. LCV appears as a huge complex for diagnostics and vaccine production. It can be assisted to expand the molecular biology facilities for diagnostics and recombinant vaccine production. Also there is a toxicology laboratory currently working on pesticide residues on fruit and vegetables, some of which are for export. The laboratory was built through USAID support that also provided training for the staff in toxicology. It is well equipped but appears congested.

The Institute for Rural Economy (IER)

This is the largest of the national research institutions for agricultural research in Mali. IER has very little biotechnology capacity at the moment. There are very few trained staff in biotechnology. Any biotechnology associated research is with external institutions. The ongoing biotechnology research program is with Texas A & M University in molecular marker determination for resistance to panicle bug (*Eurystylus marginatus*—an insect that sucks grain in sorghum), drought tolerance, molecular characterization in sorghum, grain mold infestation in sorghum, and sorghum photoperiodic sensitivity. The above collaborative works involve Malian graduate or postgraduate students at Texas A & M. University. The main constraints for biotechnology at IER are lack of laboratory infrastructure and trained manpower. Two breeders are undergoing training in molecular techniques at Texas A & M. The biotechnology research projects ongoing or planned in Mali are summarized

in Tables 11 and 12. They relate mainly to micropropagation in the plant sector and diagnostics and vaccine production in the animal sector.

Outlook

The most crucial biotechnology capacity need in Mali (as it is for Burkina Faso) is to improve laboratory infrastructure, which is currently low (Table 2) and improve manpower skills on cell and molecular biology. The manpower strength is comparable to that of the Côte d'Ivoire but lower than the rest of the countries of the subregion (Table 3). IER, which is the biggest agricultural institution in the country, appears the weakest in both trained manpower and laboratory infrastructure. There is, therefore, the need to harmonize biotechnology research in various institutions in the country under a cost-sharing arrangement as an interim measure. A scenario that could be suggested is for LCV, IER, FAST/LMBA, and IPR Katibougou to pool resources for molecular biology and tissue culture work in Mali, but there is the problem of possible monopoly by the host institution. All relevant institutions should have unrestricted access to such a central laboratory within limits of guidelines to be set.

A similar idea of collaboration mooted at the national biotechnology and biosafety workshop in June 2002 did not lead to consensus for this reason. The human problems in this regard are serious. Transparency is key for such a collaborative framework to succeed. A workable memorandum of understanding backed by some government coercion will have to be worked out to allay the fears of IER, the biggest of the NARS, who might be anxious to have their own facilities. As capacity is built to the point of needing expansion, new facilities could be created at IER. Beginning with tissue culture, a series of crash, short-term training can be designed for technicians and researchers likely to use biotechnology tools in their research. Such training can be offered in Mali and other institutions in the subregion like those of Cameroon, Côte d'Ivoire, Ghana, Senegal, IITA, and WARDA (only for rice anther culture). For collaborative biotechnology work in Mali, it is suggested that FAST, the Katibougou tissue culture laboratory, and LCV provide bench space for IER biotechnology work. For tissue culture, IER can have hardening facilities like screenhouses to begin with. IER can also have fermentation facilities since these, other than the vaccine production laboratory, are not yet established in Mali. It can use this for work in rhizobia, mycorrhiza, and food fermentation.

Table 11. Plant biotechnology research project in Mali.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Micro-propagation	Potato	Tissue culture	IPR/IFPRA	Mini- and microtubers	Commercialized	SIC International
Improving grain quality	Sorghum	Anther culture	IPR/IFPRA	Improved sorghum	Ongoing	(France) Government
Fermentation of fruit juice	Mango	Fermentation	IPR/IFPRA	Vinegar	Ongoing	Government
DNA marker identification for biotic and abiotic stresses	Sorghum	Molecular markers in sorghum for resistance to <i>Striga</i> , sorghum head bugs, drought, photoperiod-sensitivity, grain mold	IER	Various markers	Planned	Government

Table 12. Animal biotechnology research projects in Mali.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Control of CBPP	Vaccine	Fermentation Molecular markers	LCV	Recombinant vaccine	Ongoing	Government
Molecular diagnostics of various diseases	Protocols	Molecular markers	LCV	Diagnostic kits	Ongoing	Government

United States Agency for International Development (USAID) biotechnology plans

USAID is about to start a capacity-building initiative in agricultural biotechnology in Mali. The author was therefore requested to consult with the USAID office in Mali to discuss possible areas of intervention following the tour of the country. This would be in anticipation of a formal request for assistance from the Malian authorities. The USAID contact person in Mali was Dr Dennis McCarthy. He is the Team Leader of the Sustainable Economic Growth Initiative in Mali. He presented a framework on the Sustainable Economic Growth Initiative and indicated increasing income from selected agricultural subsectors in Mali as one of the goals. For this to be realized, the framework indicated three intermediate results that would have to be attained: an increase in (i) production of selected agricultural products in targeted areas, (ii) trade of selected agricultural products, and (iii) access to finance. The targeted commodities, whose production needs to increase, are rice, animal feed, fruit, and vegetables. Some of the key interventions proposed are in training, access to agricultural inputs, technology development, and transfer and capacity building. To realize the expected increase in volume of trade, most of the commodities, i.e., cereals, livestock, fruit, and vegetables, should enter trade in the subregion.

The trade and environmental policies and necessary product qualities to enter trade would need to be revised and new policies introduced as appropriate. Key activities to promote subregional trade include market information, management information system (MIS) capacity building, and monitoring of food safety and pesticide residues, among others. As much as possible barriers to trade in agricultural commodities would have to be removed. USAID Mali is especially interested in a review of the existing seed regulations to facilitate trade. The phytosanitary regulations need to be reviewed to facilitate seed trade. The existing regulations may be too stringent. Also IPR issues need to be included in this review as this relates to the movement of new cultivars. According to the Team Leader, the USAID office in Mali will assist in capacity building for biotechnology if this is linked with the above areas. It would appear to this author that all the above activities could benefit from biotechnology intervention in Mali if the institutional capacity for agricultural biotechnology is strengthened. For instance, to enhance production in the key sectors listed such as fruit and vegetables, the use of tissue culture will greatly increase the volume of quality planting material which could be grown under irrigation. Specific commodities to benefit from tissue culture under irrigation include bananas, onions, and potatoes, the capacity for which is rapidly developing at the biotechnology facility at Katibougou. Also to add value to excess mangoes that could not be sold, protocols are being developed to isolate bacterial cultures to convert excess fruit to vinegar. The research institutions to do this at the research and pilot scaling-up levels lack the bioreactors and molecular tools to facilitate ongoing initiatives listed in the biotechnology research projects matrix for Mali in this report. Through anther culture, high yielding sorghum and rice cultivars may be developed and would enter regional trade.

Hitherto the development of plants resistant to intractable parasitic weeds like *Striga* and insect pests has been painfully slow. These can be speeded up through the use of molecular markers to identify resistant cultivars. Eventually, intractable insect pests and diseases that limit the volume of the affected commodity in trade would have to be transformed by the creation of GM crops. An initiative to use molecular techniques to identify resistant sorghum cultivars to drought and insect pests is ongoing in IER in collaboration with Texas A & M University, USA. IER grossly lacks the human and material capacity to use this new tool effectively. It is desirable to provide the two molecular biology staff of IER under training in the USA the tools to work with locally on the completion of their training and return home. There is a more serious problem with effective implementation of existing phytosanitary regulations due to inadequate training and lack of the laboratory tools being evolved for rapid diagnostics than is the problem with obsolete regulations. What is more, Mali by itself cannot drastically modify the existing plant quarantine protocols without reference to the Inter African Phytosanitary Council of the African Union's guidelines which are in turn linked to the framework of the International Plant Protection Convention which governs subregional movement of plant material. USAID can assist with funding for training staff in effective quarantine procedures using the right tools. With the introduction of GMOs in World Trade, the assistance of Mali not only to develop its biosafety framework but also to be able to implement it will be a step in the right direction. The implementation of any biosafety protocols will require a priori capacity in biotechnology, which needs nurturing in Mali. In summary, USAID could help build capacity in Mali through:

- Training linked to specific biotechnology projects initiated. Linkages with specific US universities as for the ongoing in sorghum biotechnology between Texas A & M and IER, or new linkages with IARCs such as IITA and WARDA (for rice) should be encouraged. Sponsorship of training within the subregion in many cases will prove more cost effective.
- Assisting to harmonize the institutional framework for biotechnology as suggested above under the pooling of biotechnology resources in Mali. Some USAID input in the sourcing and location of resources for effective usage will be required.
- Assisting Mali to draw its biotechnology and biosafety policy document using the June 2002 biotechnology, biosafety, and intellectual property workshop report as a starting point.
- A series of biosafety workshops including hands-on training in the implementation of biosafety protocols as well as a sensitization to intellectual property issues in germplasm protection and trade.
- Other areas of USAID support can be determined from the constraints listed under institutions in Mali.

Discussions held with the Syngenta representative in Mali, Dr Oumar Niangado, indicate that Syngenta would be willing to team up with USAID to offer biotechnology capacity building support to Mali. Syngenta, the Rockefeller Foundation, and USAID sponsored the June 2002 biotechnology workshop in Mali.

Nigeria

In the 2000 survey, 17 research institutions in Nigeria were contacted. This time, however, only seven research institutions could be contacted but these represented a cross-section of the institutions in the national research system in agricultural biotechnology. The research institutions surveyed were the Biotechnology Advanced Laboratory (BAL) within the Sheda Science and Technology Complex (SHESTCO) at Abuja, the National Veterinary Research Institute at Vom, and in Ibadan, the National Center for Genetic Resources and Biotechnology (NACGRAB), the Institute of Agricultural Research and Training (IAR&T), the National Plant Quarantine Service (NPQS), the Cocoa Research Institute of Nigeria (CRIN), and the National Institute of Horticulture (NIHORT). In addition to the questionnaire, return visits were paid to NPQS and to BAL and officers connected with the biotechnology initiative in the country.

NPQS

The NPQS is a unique facility in Nigeria and in the subregion in view of its use of a biotechnology tool, namely, tissue culture in the conduct of its plant quarantine services. The person in charge of the laboratory is Mr G.O. Adejare. Relative to the 2000 survey period, there has been heightened activity in the screening of imported, vegetative, propagated plant material. Such material came in as tissue culture material or as whole plant material. As part of the service, importers paid a fee to defray the costs of services rendered to clean material if found contaminated or rescue dying plant material before release. Some of such material also went into the in vitro gene bank to increase the quantity and diversity of germplasm in storage that could be released on demand. From the plant quarantine activities there appears a growing awareness of the need for tissue culture material in the country. The acute constraints of frequent power cuts and low voltage still bedevil the NPQS.

The National Veterinary Research Institute (NVRI)

Due to time constraints a much wanted visit could not be paid to the National Veterinary Research Institute at Vom. The questionnaire returns revealed an acute shortage of staff trained in molecular techniques. The only recruited staff member in the area was undergoing postgraduate training. The laboratory facilities are also unsatisfactory and will need major refurbishing and re-equipping.

SHESTCO

The Sheda Science and Technology Complex (SHESTCO) is a science village in Abuja established in 1993 and has Dr J.D. Coker as its Director General. SHESTCO is being built and equipped by the Nigerian Government, which in recent times increased five-fold its budgetary allocation to the Federal Ministry of Science and Technology. SHESTCO currently houses the following centers of excellence: the Nuclear Research Institute (90% equipped and due to start operation in June 2002), the Physics Research Institute, the

Chemistry Research Institute (ready for occupation as at the time of visit in May 2002), and the Biotechnology Advanced Laboratory (BAL). This laboratory is under construction and will have very modern facilities for biotechnology research. Construction is expected to be completed in 2002. BAL currently shares space with the Physics Research Institute.

The Biotechnology Advanced Laboratory (BAL)

BAL is a component of the national framework for biotechnology development listed in the National Biotechnology Policy Document of 2001. Prof. G.H. Ogbadu is the Director of the laboratory. The mandate of BAL is “to provide a center of excellence for research and training in biotechnology and genetic engineering”. The objectives are to promote scientific activities that will lead to developing peaceful uses of biotechnology and genetic engineering, to assist in strengthening the national science and technology capabilities in the field of biotechnology and genetic engineering, to serve as forum for information exchange experience and know-how among scientists in the field of biotechnology and genetic engineering, and to establish close collaboration with the private sector, the end-users of Research and Development effort. The short-term (2–3 years) plan of action is to concentrate on tissue culture of food and tree crops, bioinformatics (data gathering and processing), fermentation (baker’s yeast production, antibiotic production, industrial enzyme production), botanical health products production including nutraceuticals and food flavors, training, and networking. The medium-term (4–10 years) plan is to focus on plant transformation technology of agricultural and industrial crops (e.g., introduction of gluten genes into cassava, nutrient fortification of food crops or biofortification), genomics, bioremediation, and molecular tools for plant characterization. The long-term plan includes genomics and proteomics, diagnostics, and further work on transformation. There is strong collaboration with Rutgers University in the USA and biotechnology firms worldwide.

Outlook

Nigerian manpower in biotechnology revealed by the current study (Table 3) is a gross underestimation of the actual situation on the ground. This is due to the fact that the current survey sampled much fewer institutions and most of these were outside the university system, which houses the bulk of biotechnology manpower for Nigeria. None of the available manpower had training in biosafety (Table 2). However, in terms of research activity and research infrastructure, the survey results are a reflection of the national picture. As it is for most countries in the subregion, tissue culture facilities are fairly satisfactory but those for molecular biology are woefully inadequate and probably the worst in the subregion. The summarized agricultural biotechnology research is dominated by tissue culture work in plants (Table 13) and classical vaccine production practices (Table 14).

Nigeria has in recent times exhibited great commitment to the use of biotechnology as a tool to enhance agricultural and general socioeconomic development. Biotechnology development policy and biosafety guidelines have been drawn, and institutions to promote biotechnology research and development and its linkage with entrepreneurs established.

Table 13. Plants biotechnology research projects in Nigeria.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Micro-propagation	Fruits crops, forest trees, banana, plantain, pineapple	Tissue culture	BAL-SHESTCO NIHORT (banana, plantain, pineapple)	Plantlets for mass propagation	Protocols (forest trees) Transferred (<i>Musa</i> spp. by IITA, and pineapple)	Government
In vitro germplasm conservation	<i>Musa</i> , cocoyam fruit, medicinal plants, African bitter leaf (<i>Vernonia amygdalina</i>), endangered plant species	Tissue culture	NACGRAB	Plantlets in vitro	Completed (<i>Musa</i> spp. with the aid of IITA, cocoyam, passion fruit), protocol development (medicinal plants, endangered species)	Government
Somaclonal variation	Kenaf, cocoa, coffee, cashew, kola, tea	Tissue culture	IAR&T/OAU (Kenaf only) CRIN	Uniform Plant material	Ongoing	Government STCP/IITA for CRIN mandate crops
Double-haploid	Maize	Anther culture	IAR&T/OAU	Stable hybrids	Ongoing	Government

.../continued

Table 13. (Cont.)

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Screening and isolation of local yeast strains	Yeast	Fermentation	BAL-SHESTCO in collaboration with Xechem Int. NJ, USA	High potential local baker's yeast strain	Characterization	Government
Industrial enzyme production	Enzymes	Fermentation	BAL-SHESTCO	Industrial enzymes for the food industry	Isolation and characterization	Government
Biocontrol of pests of and disease	Tree crops	Numerous classical techniques	CRIN	Biocontrol agents	Planned	Government
Biofertilizer and biogas production	Crop waste	Fermentation (classical)	CRIN	Energy source	Planned	Government
Phytosanitary services	Imported vegetative material, including cassava, potato, onion, sweetpotato	Tissue culture	PQS	Clean plant material	Routine service	Government

Table 14. Animal biotechnology research projects in Nigeria.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Vaccine production	Vaccines	Fermentation (classical)	NVRI-Vom	Vaccines	Ongoing	Government
Diagnostics	Diagnostic protocols	Molecular markers	NVRI-Vom	Diagnostic kits	Planned	Government

These policy interventions will be treated in greater detail elsewhere in this report. Despite this, the available level of manpower and infrastructure support to enable Nigeria to realize her dream is weak.

USAID has responded to Nigeria's call to assist in building capacity to use the tools of modern biotechnology development in relevant fields. The USAID mission in Nigeria responded to the call and has drawn a program to assist Nigeria with the following objectives:

- To build scientific and institutional research capacity in agricultural biotechnology through collaborative technology development and training with US and other international institutions.
- To build capacity for designing and implementing effective policy options, biotechnology research and technology transfer, both at the institutional and national levels.
- To access proprietary biotechnology tools and to promote and manage use of the technology.
- To promote understanding between a diverse set of stakeholders on the issues to enhance technology development and dissemination, and ensure the safe and judicious applications of biotechnology.

This is with a view to maximizing its potential benefits while avoiding to the maximum extent possible adverse effects on human health and the environment. The program components are technology development and capacity building. USAID will support collaborative technology development between IITA and Nigerian institutions (research institutions, universities, and the private sector) to integrate the tools of biotechnology to support agriculture. Both crop and animal biotechnology will be addressed.

On capacity building, emphasis will be on developing and conducting courses and workshops, and hands-on, short training through learning-by-doing. This program will also aim for sensitization and biotechnology outreach activities to adequately sensitize the general public on biotechnology issues. Balanced information on biotechnology will be given. Last but not least, the program will work on biosafety policy and regulation through human resource development and institutional infrastructure capacities, which will be strengthened to assist in the implementation of the National Biosafety Guidelines. IITA will assume the leadership role in helping Nigeria build the needed capacity with funding provided by USAID. It is evident from the current survey that USAID will need to channel resources into training at all levels in biotechnology, especially in the use of molecular biology techniques for plant characterization, diagnostics, and subsequent plant genetic transformation. The use of modern molecular tools in the animal sector is badly needed, and this capacity is currently not available in Nigeria, so the project with IITA as implementing agency will bring ILRI as subcontractor to address livestock biotechnology when and as appropriate. USAID assistance will be needed to rapidly build local capacity in plant transformation to obtain a hands-on test case for the application of the biosafety guidelines. Any advanced training in molecular biology should incorporate the solving of a local problem into the training scheme. Although tissue culture capacity at the research

institution level is gaining ground, the same cannot be said of the private sector that must be assisted to develop the capacity to commercialize the technology.

Senegal

All the institutions in agricultural biotechnology at the Institut Sénégalais de recherche agronome (ISRA) that were surveyed in the 2000 period were also surveyed in 2002. These were the Laboratoire national d'élevage et de recherches vétérinaires (LNERV), the Laboratoire de microbiologie/Institut de recherche pour le développement/Université Cheikh Anta Diop (LM/IRD/UCAD), and the Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse (CERAAS). The new additions were the Faculty of Sciences and Techniques, the Plant Biology Department of UCAD, and the Institut de technologie alimentaire (ITA). Apart from ITA, all the above institutions belong to Ministry of Higher Education and Scientific Research. ITA belongs to the Ministry of Mines, Artisans and Industry. ISRA is currently formulating its policy on biotechnology according to its Director General Dr Papa Seck. The policy will cover both traditional and modern biotechnology.

ISRA-IRD

The contact person for an ongoing ISRA-IRD project is Dr Mamadou Gueye, who is the head of the Microbiology Unit. This is a Soil Microbiology Laboratory mainly concerned with N-fixation work. Rhizobia strains most competitive against native rhizobia are selected. The laboratory uses DNA probes to identify if the introduced rhizobia are indeed the ones nodulating. They compare the PCR products of the introduced rhizobia with the native one isolated from the nodules. Rhizobium inoculum is routinely distributed to farmers for *Phaseolus* bean production. *Phaseolus* bean is for export. The carrier for this is peat. The laboratory also produces liquid inoculum for other tree legumes (*Gliricidia*, *Leucaena*, and *Acacia nilotica* among others). Rhizobia isolates must be both efficient in N-fixing and competitive against native rhizobia. Now emphasis on N-fixation is for all microorganisms around the roots; i.e., the rhizosphere. The ISRA-IRD-UCAD laboratory is the center of excellence for biological nitrogen fixation (BNF) in the subregion. It is also a UNESCO-MIRCEN (Microbial Resources Center). Through MIRCEN it offers fellowships to visiting scientists in the subregion. The modern tissue culture laboratory adjacent to the microbiology laboratory was temporarily shut down for lack of running capital to handle utilities.

LNERV

The Animal Biotechnology Unit, LNERV, focuses on artificial insemination of horses and bovine, embryo transfer—which is at experimental stage, and vaccines—both inactive and live vaccines are produced. There is a desire to move into recombinant vaccine production in collaboration with CIRAD and the University of California at Davis. Candidates for recombinant vaccine production are anthrax and blackleg. LNERV is developing diagnostic kits for rinderpest using molecular tools (monoclonal antibodies). Dr Mamady Konte, a

microbiologist/molecular biologist is the head of the microbiology unit of LNERV. The vaccine development unit and the viral disease diagnostics work is headed by Dr Yaya Thiongane. About 5000 cattle head—for milk production—were inseminated by the government over the 1999–2000 period. They used Holstein, Jersey, and Montbeliard cattle semen in the National Artificial Insemination Campaign. This campaign was launched as that for vaccination. The Ministry of Agriculture and Livestock supervised the campaign. ISRA will monitor the outcome of the insemination. A FAO project dealing with characterization of livestock genetic resources and the establishment of a gene bank on the hoof is ongoing. The gene bank is located at Sangalkamp near Dakar, and construction of the camp is ongoing. Samples of all indigenous livestock species in Senegal are to be kept at the camp. Senegal is an active member of BIONET INTERNATIONAL—the Global Network for Taxonomy. The West African branch is WAFRINET. BioNET is a creation of Centre for Agriculture and Biosciences International (CABI), UK.

CERAAS

The contact persons at CERAAS are the Center Director, Dr Roy-Macauley and the Scientific Program Coordinator, Dr Sergé Braconnier, on secondment from CIRAD. CERAAS is a CORAF/WECARD base center or specialist center, which acts as both a national center (being an ISRA institute) and as a regional center (under the umbrella of CORAF/WECARD). The EU supports the regional work whilst ISRA funds its national research. CERAAS moved from Bambey to the present station at Thies near the UCAD Agricultural College in 1997. The EU is the main donor for CERAAS, whose mandate crops are cowpea, groundnut, pearl millet, and sorghum but sometimes undertakes research on other crops like sesame, oil palm, and maize according to requests from national partners in Senegal or the subregion. CERAAS provides training for technicians (short term) and for scientists for trials (long term). For long term, the duration is 1 to 2 years, though 2 to 3 years may be preferable. CERAAS advertises for students and gives stipends, and also links up with UCAD for postgraduate MSc and PhD training.

Currently there is no molecular biologist at CERAAS but the Director has background training in the area and fills in. A molecular geneticist from CIRAD is expected to join CERAAS later in the year. A member of staff from ISRA is currently doing a PhD in molecular biology in France. The center requires two full-time molecular biologists. Two areas of focus in molecular biology at CERAAS are functional genomics of enzyme systems for tissue integrity during drought, and structural genomics for marker characterization to aid breeding for drought tolerance. This work is done in collaboration with the Faculty of Science, UCAD and funded by the Government of Senegal. CERAAS has adequate infrastructure for regional biotechnology work. Such facilities are currently underutilized at the station. Currently, there are accommodation problems for visiting scientists but this will hopefully be resolved by the end of the year. A new training center with accommodation for 6 to 8 persons will be built with EU support. Students on attachment and visiting scientists are currently housed at the Ecole nationale supérieure d'agriculture (ENSA) agricultural school of the state.

All field-work is done at the Bambey station while lab work is done at the Thies station. There is no direct linkage with farmers but this will change when an agronomist is seconded from ISRA. Senegalese staff at CERAAS are paid by ISRA with topping up by CERAAS but to a level lower than that for international staff. Currently there are eight scientists including a biometrician working at CERAAS, but the target is 15 PhD professionals. There are research-for-development linkages with UCAD, advanced research labs, IITA, and EU Universities. Important constraints are the risk of the EU being the sole source of significant funding, an inadequate core budget, staffing problems, and difficulty with procuring laboratory reagents because supply sources are unreliable.

Faculty of Science, UCAD

The Dean of the Faculty of Science and Techniques at UCAD is Prof. A. Sall while the Head of the Biotechnology Unit is Dr Yeye Kane, a molecular biologist. The biotechnology laboratory, which is in the Plant Biology Department, works on both tissue culture and molecular biology but tissue culture is the dominant activity. The ongoing tissue culture activities are meristem culture, somatic embryogenesis, haploidization leading to anther culture, salt tolerance in cereals, and forest tree (*Acacia*) mass propagation. There are plans to start work on sheanut soon. Ongoing work also includes tissue culture of date palm (to get cultivars maturing before or after the rains), cassava, *Balanites*, and yambean (whose leaves and seeds have the acaricidal properties). The UCAD laboratory is now the main tissue culture lab in Senegal with the closure of the one at ISRA. Once the necessary awareness has been created, farmers will demand tissue culture material. For instance, through sensitization by an NGO in Senegal, ENDA, farmers are asking for tissue culture plantlets of potato, yam, and sweetpotato. There is also a request for cassava tissue culture plantlets. Both the tuber and leaves of cassava are used in the diet. Some yams are medicinal and produced as tissue culture material on demand.

Molecular biology research is ongoing in characterization of cowpea genetic diversity. Molecular markers for high nitrogen fixation in cowpea are being sought. The laboratory has identified high and low nitrogen fixing cowpea varieties and tracing for markers in the lines. The work on cowpea molecular characterization is with CERAAS. Funding for the cowpea research is provided by the IAEA. The Faculty of Science at UCAD is running postgraduate courses in biotechnology at masters and doctorate levels. The Faculty is planning the start of a new one-year, postgraduate, international course in biotechnology designed for entrepreneurs. Resource persons from both within and outside Senegal will be used. Teaching will be both in English and French. The course will offer three areas of specialization, namely, tissue culture, fermentation, and animal health product production like vaccines and diagnostic kits. UCAD will require external assistance to begin the course.

ITA

The contact persons at the Institute of Food Technology (ITA) are the Director of the Institute, Dr Ababacar Ndiaye and the Industrial Microbiologist Dr L.S. Tounkara, who is

the scientist in charge of the activities of the biotechnology unit. The ITA biotechnology unit started in 1992 with 70% of the funding required coming from Senegal–Belgium cooperation. The laboratory is the best-equipped industrial fermentation laboratory in the subregion. It has two liter fermentors or bioreactors for laboratory-scale work and 100 liter fermentors or bioreactors for pilot-scale work. The biotechnology unit also fabricates equipment and food processing equipment including pasteurisers to assist in the transfer of their technologies to entrepreneurs who might lack the needed equipment. Research areas include work on traditional milk (*balik*) or sour milk production. The ongoing microbe characterization aims to select appropriate bacteria for starter culture production, which will ensure controlled fermentation. Also they are researching on *soumbala* (*dawadawa*) or fermented dehulled locust bean (*parkia*). Bacteria responsible for the fermentation have been isolated and the starter culture production started.

The technology is being transferred to a private food company to begin the commercial production of *soumbala*, a popular condiment in West Africa. ITA has isolated numerous strains of the bacteria that have different flavor characteristics. Soybean and cowpea have also been successfully used to produce the product. The Japanese produce a similar product called “natto”. An export market could be developed for the product. The laboratory collaborates with the Craft Brewing Business Institute (CBBI) (Belgium) for *soumbala* and other fermentation work. Improved vinegar is produced using bacteria isolated from mango fruit juice used as culture. Vinegar has been successfully produced from excess mango fruits that would otherwise go to waste. This technology is at the transfer stage. Other products are mushroom spawn (about to start) for distribution to farmers and the production of xanthan gum isolated from *Xanthomonas campestris*. The gum when added to flour from local cereals like millet and sorghum that have no gluten, allows dough to rise during fermentation without the need to add wheat flour as in composite flour for bread. ECA and the Government of Japan are funding this project.

Outlook

The laboratory infrastructure (Table 2) and manpower for agricultural biotechnology (Table 3) in Senegal is among the best in the subregion. The standard of biotechnology work is relatively more advanced than a number of countries in the subregion (Tables 15 and 16). There is a good spread in the use of biotechnology tools.

General Biopolicy Issues in West and Central Africa

Intellectual property and impact assessment capability of the NARS

Most of the NARS contacted indicated very low capability for intellectual property management (23%) and 50% for impact assessment (Table 17). In view of the growing importance of intellectual property (IP) for accessing proprietary technology in biotechnology and benefit sharing in plant genetic resources, a heightened awareness in IP matters among the

Table 15. Plant biotechnology research projects in Senegal.

	Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
42	Micro-propagation	Potato, sweetpotato, cassava, yams, <i>Pachyrus erosus</i> , medicinal plants, savanna reforestation trees	Tissue culture	UCAD-Faculty of Science	Plantlets	Completed or ongoing for new introductions	ENDA
	Somatic embryogenesis	<i>Bambusa</i> spp., <i>Hibiscus sabdarifa</i> , <i>Phoenix dactylis</i>	Tissue culture	UCAD-Faculty of Science	Plantlets	Ongoing	Government
	Drought tolerance	Cowpea	Molecular markers and QTL analysis	CERAAS with CNRA/ISRA, UCAD, Fourah Bay College, Univ. Sierra Leone Lab. de biochimie l'adaptation végétale (LBPAV)	Molecular markers to identify QTL for drought tolerance in cowpea	Ongoing	FNRAA EU-EDF

Table 15. (Cont.)

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Biological nitrogen fixation	Rhizobia	Fermentation molecular markers	Univ. de Paris, CIRAD and soon IITA ISRA in collaboration with IRD and UCAD	Rhizobia inocula	Technology transferred to	UNESCO IAEA FAO
Characterization of entire microbes in root zone	Soil microbial ecology	Microscopy molecular characterization	ISRA with IRD and UCAD	Various inocula including rhizobia and mycorrhizae	Ongoing	UNEP
Isolation and production of starter cultures for food fermentation	Fermented foods: soumbala (dawadawa), yoghurt, mango juice, vinegar and wines from fruit juices	Fermentation	ITA	Starter cultures	Completed and technology transferred	DGIC (Belgium)
Production of microbial metabolites	Amino acids, enzymes, vitamins, flavors, antibiotics, biopolymers (xanthan gum)	Fermentation	ITA	Protocols established for xanthan gum-leaving of dough from local cereals for baking	Ongoing but xanthan gum production completed	JICA

Table 16. Animal biotechnology research projects in Senegal.

Research area	Commodity	Biotech tool	Responsible laboratory	Product desired	Development stage	Sponsor
Rapid diagnostic procedures	ELISA kit for rinderpest, African swine fever surveillance	Molecular markers	ISRA-LNERV In collaboration with PACE and Univ. California at Davis	Diagnostic kits	Validation	IAEA
Control of various epizootic diseases	Vaccines for Newcastle disease and Rift Valley fever	Molecular markers	ISRA-LNERV	Bivalent vaccine	Developing protocols	FAO

Table 17. Intellectual property and impact assessment capability of NARS in West and Central Africa.

Criteria	Responding positively (%)
Intellectual property	23
Impact assessment	50

NARS is imperative. This can be assessed through training arrangements. It would appear that more NARS have been exposed to impact assessment courses than is the case with IP. In the past, Institut du Sahel (INSAH, Bamako) as well as CSIR (Ghana) organized impact assessment short courses with the assistance of Purdue University. Such initiatives should be revisited.

Constraints facing biotechnology research in the NARS of the subregion

Given the constraints cataloged for each of the NARS, the current biotechnology output appears commendable. The NARS that are better endowed with infrastructure generally appeared more active. Most of such NARS received external donor support. The constraints facing the NARS are summarized here from the perspective of the NARS in the various countries. It is imperative that any effort at addressing the gaps in biotechnology in the subregion considers these constraints.

A key constraint for which there was persistent requests by the NARS was training at both researcher and technician level for both biotechnology and biosafety. Every country visited highlighted this. Next to this was laboratory infrastructure followed by funding and public awareness, in that order. The availability of laboratory spare parts and trained repair technicians was a major concern to most NARS and ranked equally with the lack of public awareness (Table 18). Surprisingly, poor private sector linkage, which was obvious in all countries visited, was ranked by only Côte d'Ivoire. Perhaps if the level of public awareness is enhanced and the major constraints of research output are addressed, the NARS can with confidence engage in meaningful dialog with the private sector. However, if the example of ENDA (NGO in Senegal) is anything to go by, awareness creation followed by a proactive link with the private sector can lead to private sector contribution to the provision of infrastructure. Agreements can be made to produce commodities for the private sector. Payments to defray the cost of the private investment can be made in the infrastructure. A similar arrangement is ongoing in Mali between the tissue culture laboratory at Katibougou and a private company for the production of potato planting material. Electricity supply problems were common in most countries visited but most acute in Nigeria, the only country listing this as a major constraint.

The level of political commitment to biotechnology development among countries in the subregion is variable. In recent times, the government of Nigeria has increased the

Table 18. Biotechnology development constraints facing West and Central Africa from NARS own perspective.

	Countries						
	Burkina Faso	Cameroon	Côte d'Ivoire	Ghana	Mali	Nigeria	Senegal
Key constraint							
Laboratory infrastructure	X	X		X	X	X	X
Funding		X		X	X	X	X
Training/manpower	X	X	X	X	X	X	X
Public awareness			X	X		X	X
Biosafety legislation			X		X		X
Information access and technology		X			X	X	
Laboratory chemicals				X	X	X	
Poor private sector linkage			X				
Electricity						X	
Spare parts and repair technicians	X	X		X			X
Poor political commitment		X					X
Lack of current journals	X						

Presence of constraint indicated by an "X" in the appropriate cell.

budgetary allocation to the Ministry of Science and Technology for the development of biotechnology.

It was only one country, Burkina Faso, which indicated that the acquisition of current journals was a constraint. It is safe to say that this will be a problem across all countries. The current journals are published in Europe and North America and to get these, scientists have to pay in hard currency.

Awareness of CORAF/WECARD activities by the NARS in West and Central Africa

The issue of awareness of CORAF/WECARD activities by the NARS of the subregion becomes an issue when a regional framework initiative for biotechnology is to be sought with the subregional organization playing the dominant coordinating and facilitating role. This brings to question the capability of the subregional organization to reach its key research partners. In this regard both the traditional NARS partners of CORAF/WECARD and the universities were examined for various awareness criteria. The universities are not traditional CORAF/WECARD partners but they have capacity for biotechnology and collaborate actively with the NARS members of CORAF/WECARD. In all, 25 NARS and seven agricultural biotechnology active universities were surveyed in the subregion. These were the same institutions used in the current biotechnology survey exercise. The level of awareness of various key CORAF/WECARD activities was low among the NARS and universities (Table 19). All the seven universities across both Anglophone and Francophone countries gave a zero rating for all the listed CORAF/WECARD activities.

Table 19. Subregional awareness of CORAF/WECARD activities by the NARS of West and Central Africa.

CORAF/WECARD activity	Responding positively (%)
Attendance at meetings	31.2
Participation in research networks	21.9
Information received regularly	31.2
Information received occasionally	31.8

Out of 32 NARS surveyed, seven were university departments.

It would appear that CORAF/WECARD has to revamp its machinery to be able to reach all its constituents in the subregion and ensure effective participation in all its subregional activities. An effort has to be made to reach out to university departments in general agricultural and biotechnology research to bring on board the talents and capabilities in agricultural biotechnology and agricultural research in these institutions.

Biopolicy and issues of national commitment to biotechnology and biosafety

In general, there is more awareness at government level on issues of biotechnology and biosafety now in the West and Central African zone than was the case in 2000. However, for the most part, the growing awareness has been on issues related to biosafety than to the use of the tools of biotechnology to produce useful products (Table 20). The exception is the case with Nigeria, which has elaborated its national policy on biotechnology with action plans on policy implementation (FMST 2001). Arising from the Nigerian policy document is the creation of a National Biotechnology Development Agency (NABDA) to coordinate and promote biotechnology research and development, training, entrepreneurship development, and awareness creation. The Biotechnology Advanced Laboratory earlier mentioned is an outcome of the renewed thrust in biotechnology. The Nigerian initiative is driven by a committed Head of State, who sees the potential of biotechnology as a tool for the nation's socioeconomic advancement. Côte d'Ivoire and Senegal have also shown commitment to varying degrees, but in the case of the latter, this has been propelled more by donor initiative and enlightened NGO support to a university biotechnology facility. Côte d'Ivoire has established a committee to develop the nation's biotechnology policy while Mali has recently (June 2002) held a national workshop to deliberate on the way forward in biotechnology. Ghana—under a World Bank loan within the Agricultural Sub-Sector Investment Program (AgSSIP)—is investing about US\$165 000 to expand and modernize the molecular biology laboratory of the Crop Science Department of the University of Ghana. Part of the AgSSIP loan is to meet the running costs of the molecular biology laboratory of the CSIR-Oil Palm Research Institute Coconut Development Project. These infrastructure developments

Table 20. Level of government commitment to issues of biotechnology in West Central Africa.

Country	Key ministries	Commitment	Nature of commitment	Available national biotech policy document
Burkina Faso	Ministry of Higher Education and Scientific Research, Ministry of Environment	Committed	Biosafety Drafting Committee established	No
Cameroon	Ministry of Higher Education and Scientific Research, Ministry of Environment and Forestry	Committed	Biosafety law at point of legislation Ratified Cartagena Protocol on Biosafety	No
Côte d'Ivoire	Ministry of Higher Education, Ministry of Environment	Highly committed	Biosafety law at point of legislation. Promoting the establishment of a modern Central Biotech Laboratory	No
Ghana	Ministry of Environment Science and Technology	Committed	Draft biosafety framework published pending legislation	No
Mali	Ministry of Higher Education, Ministry of Environment	Committed	Policy definition	No
Nigeria	Federal Ministry of Science & Technology	Highly committed	Biotechnology policy enacted. Biosafety law at point of legislation. National Biotechnology Development Agency established. Biotechnology Advance Laboratory (under construction) in a science village created.	Yes
Senegal	Ministry of Higher Education, Ministry of Environment	Committed	Just starting the national biosafety framework development process with awareness seminars.	No

are scheduled to start this year. Cameroon as reported in the 2000 biotechnology survey report (Alhassan 2001) got a US\$8 million African Development Bank loan to revamp the agricultural research infrastructure including the tissue culture facility at Ekona. However this is yet to start at the Ekona laboratory.

All countries in the subregion took varying actions on biosafety ranging from taking steps to constitute biosafety drafting committees to bringing their biosafety framework documents to the point of legislation (Table 21). The most advanced in this regard are Cameroon, Côte d'Ivoire, and Nigeria. In the case of Nigeria, there is cabinet approval to begin implementing the biosafety guidelines pending legislation in parliament. Ghana's framework document is ready but still at the level of the Ministry of the Environment Science and Technology. Only Cameroon has ratified the Cartagena Protocol on Biosafety but all countries have signed the document and qualify for United Nations Environmental Programme/Global Environment Facility (UNEP/GEF) assistance to develop their frameworks up to the point of legislation and implementation. The criteria for sourcing the GEF funds are (UNEP/GEF 2001):

- Ability to borrow from the World Bank or to receive technical assistance grants from UNDP.
- Signatory to, or intend to ratify the Cartagena Protocol on Biosafety not later than the completion date of activities in their UNEP/GEF project.
- The country has not received assistance previously from the UNEP/GEF Pilot Project on Biosafety.
- The National GEF Focal Point formally expresses the country's interest in participating in the Project.

Cameroon, Côte d'Ivoire, and Nigeria drafted their laws in harmony with the Cartagena Protocol on Biosafety (Secretariat of the Convention on Biological Diversity 2000). The Organization of African Unity (OAU)—now African Union (AU)—produced a draft-model law (OAU 2002), which is also to serve as a guideline for member countries. However, portions of the African Model Law appear to be at variance with those of the Cartagena Protocol such as timeframes for reacting to applications (Model Law has no such timeframes), review of decisions in the light of new scientific evidence to grant a previously denied application (African Model Law has provision only to withdraw a previous permit), use of the Biosafety Clearing House to expedite import decisions in emergencies, and it has extreme labeling requirements. The Protocol requires that decisions taken on domestic law be consistent with those of the Protocol. Given the differences in the letter and spirit of the two documents, harmonization of laws in the subregion could become complicated.

Public awareness on biotechnology and biosafety issues

In order to assess the extent of public awareness on biotechnology and biosafety issues, NGOs and media houses were administered questionnaires and follow-up discussions were held with some of them. These groups were chosen because their vocal counterparts in Europe and elsewhere in the world influence negatively the course of biotechnology development and trade in genetically modified (GM) products. They could, depending on

Table 21. Status of biosafety law in selected countries of West and Central Africa.

Country	Framework drafted	Law enacted	Law being enforced	Focal point	Action on cartagena protocol
Burkina Faso	No	No	No	Ministry of Environment	Not ratified
Cameroon	Yes	No (almost ready)	No	Ministry of Environment	Ratified
Côte d'Ivoire	Yes	No (almost ready)	No	Ministry of Environment	Not ratified
Ghana	Yes	No	No	Ministry of Environment	Not ratified (pending in Cabinet)
Mali	No	No	No	Science and Technology Ministry of Environment, Territorial and Urban Planning	Not ratified (Cabinet approved)
Nigeria	Yes	No	No	Federal Ministry of Environment	Not ratified
Senegal	No	No	No	Ministry of Environment	Not ratified

their level of awareness, influence the course of development of biotechnology in the sub-region. The press in particular influence the course of public thinking through information they disseminate. A correlation has been established between increased media coverage devoted to an issue and increased public awareness (Marks et al. 2002). Eleven NGOs and 18 media houses were surveyed across the subregion. In many cases discussions with the groups was opportunistic depending on their availability.

Some of the NGOs were fully committed to environmental issues while a few had both environment and farmer-based mandates. The characteristics of media houses surveyed are shown in Table 22. For the print media, there were six public newspapers and eight private ones. All three from radio and the only one from television (Ghana Television) were publicly owned. It appeared the NGO community were better informed about biotechnology issues than the press with 54.5% of NGOs and only 25% of the press indicating some understanding of biotechnology (Tables 23 and 24). An international NGO in Senegal (Environment Development Action—ENDA), which has both a farmer technology transfer mandate and an environment mandate, sensitized farmers to the use of tissue culture material and sparked a demand among them (commercial farmers) for plantlets that they harden for the farmers. ENDA has further revamped the tissue culture laboratory at Cheik Anta Diop University to be able to produce the tissue culture plantlets for its farmers. The tissue culture material contracted from the university and distributed are date palm, agroforestry trees, and bananas. Some medicinal plants are also produced. The Cotton Producers Association in Mali had not heard of Bt-cotton but was aware of organic cotton known as “Cotton Biologie” introduced by an NGO. No inorganic fertilizers are used and no pesticides but neem are used. “Cotton Biologie” is still at the demonstration stage.

For biosafety, 45.5% of NGOs had some understanding (Table 23). Less than half of the NGOs had a positive attitude to biotechnology based on agricultural products including GMOs. While none of the press houses had a negative attitude to biotechnology and its products, an overwhelming majority were neutral, that is, did not have any fixed position. Journalists appeared to report more on science issues than on agricultural issues (Table 25). Constraints listed by journalists and accounting for the low reporting in science issues and biotechnology in particular include:

- Difficulty in getting biotechnology and science-based information from local sources to publish. Most obtained their information from the Internet or from other secondary foreign sources.
- Difficulty in recruiting science personnel for training as journalists.
- Lack of training to update knowledge on biotechnology and biosafety.
- Limited infrastructure for television reporting on science matters. Available equipment (e.g., cameras or vehicles) is dedicated mainly for social events, especially political events. Science reporting has low priority.

The recommendations by journalists to address the problems are:

- workshops and seminars to increase media awareness on biotechnology and biosafety
- encourage the enrolments of science students into journalism schools

Table 22. Characteristics of media houses surveyed in West and Central Africa.

Country	Media type (number)				Circulation level	Biotech standing (%)		
	Print Pub.	Print Priv.	Radio	TV		+	–	Neutral
Burkina Faso	1	–	–	–	Nationwide	100	–	–
Cameroon	–	–	–	1	Nationwide	–	–	100
Côte d'Ivoire	–	5	–	–	Unknown	25	0	75
Ghana	2	1	1	1	Nationwide	20	0	80
Mali	1	–	–	–	Nationwide	–	–	100
Nigeria	1	2	1	–	Nationwide	25	0	75
Senegal	1	–	–	–	Nationwide	100	–	–

All radio and TV houses surveyed were public (pub.)

Table 23. NGO reaction to issues of biotechnology and biosafety in West and Central Africa.

Criteria	Response (%)
Some understanding of biotechnology	54.5
Positive attitude to biotech agric. products including GMOs	45.5
Some understanding of biosafety	45.5
Willingness to train in biosafety	81.8
Willingness to recruit biosafety personnel	72.7

Number of NGOs surveyed = 11.

Table 24. Media commitment on biotechnology and related disciplines in West and Central Africa.

Criteria	Responding positively (%)
Availability of science desk	50.0
Willingness to recruit science correspondent	75.0
Agriculture reporting	68.8
Health and environment reporting	62.5
Understanding of biotechnology	25.0

Number of media houses surveyed = 16.

Table 25. Frequency of reporting on science and agriculture in West and Central Africa.

Area of reporting	Responding (%)				
	Daily	Weekly	Fortnightly	Occasionally	Rarely
Science	18.8	18.8	6.2	50.0	6.2
Agriculture	28.6	14.2	0	28.6	28.6

- introduce science curriculum into schools of journalism (A case was made by the Ghana Institute of Journalism to re-introduce the agricultural journalism course introduced with USAID support some years ago and to train a local instructor on agricultural journalism.)
- media houses should be encouraged to introduce science desks
- African scientists must be encouraged to open up to journalists.

An overall recommendation is for increased awareness in the media, among NGOs, and the public at large through frequent seminars, workshops, and the sponsorship of programs related to biotechnology, biosafety, and biodiversity in the print and electronic media. Research organizations in the subregion should be encouraged to disseminate information to the media and to the general public, but the NARS must be empowered to be able to generate the information in the first place.

International agricultural research centers and science promoting agencies in biotechnology in West and Central Africa

The international agricultural research centers (IARCs) active in the subregion in agricultural biotechnology are the International Institute of Tropical Agriculture (IITA), the West Africa Rice Development Association (WARDA), and to very lesser extent, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the International Livestock Research Institute (ILRI). A center that has a regional technology mandate including biotechnology is the African Regional Center for Technology (ARCT). All the IARCs have their specific mandate crops and geographic areas of operation.

IITA

The area of operation of the International Institute of Tropical Agriculture covers vast areas of the humid forest, high rainfall, dry savanna, moist coastal savanna, all of West and Central Africa, and the midaltitude areas of Eastern Africa. It has stations in the above agroecological areas and the headquarters is in Ibadan, Nigeria. The mandate crops for genetic resources and enhancement are Bambara groundnut, banana/plantain, cassava, cowpea, maize, soybean, and yam. Under its Sustainable Tree Crops Program

(STCP), its mandate extends to tree crops within the farming systems of the above agroecological zones, particularly cacao. IITA currently has about a 10-member team comprising molecular biologists, molecular breeders, tissue culture specialists, and molecular diagnostic experts. The biotechnology tools in use at IITA for each crop are given in Table 26.

Tissue culture

There is an in vitro gene bank for cassava, yam, and plantain/banana including cryo-preservation. There is an emergency relief unit for vegetatively propagated crops and delivery of new propagules to farming systems. Pathogen-tested propagules are available for export after virus indexing and diagnostics for pests.

Genetic transformation

There is an efficient, in-house, genotype-independent regeneration protocol from apical meristems of plantain and banana. A similar capacity exists for transformation and regeneration in cassava. IITA is still researching into yam and cowpea transformation and regeneration with advanced laboratories in the European Union and North America.

Marker-assisted breeding

RAPD and AFLP markers are used to determine genetic variation and phylogeny in *Musa* germplasm. AFLP and SSR markers are used to research on fruit parthenocarpy, dwarfism, and apical dominance in banana and plantain. These same markers are also used for banana weevil resistance selection.

For cassava mapping with RFLP and SSR markers for cassava mosaic disease, dominant gene mapping has been done in collaboration with CIAT in Colombia and cloning with ILTAB in the USA. For yam, genetic diversity is under study using AFLP markers. AFLP maps are available for white and water yams. In cowpea, there are genetic maps using RAPD, AFLP, and SSR. This work includes collaboration with the John Innes Centre (Norwich, UK), the University of Saskatchewan, Canada, and US universities. QTL for

Table 26. IITA Agrobiotechnology tools in seven crops.

Crop	Tissue culture	Transgenics	DNA markers	Fingerprinting
Cassava	Routine	In-house	Map/QTL	Pests, genepool
Yam	Routine	Not available	Map/QTL	Pests, genepool
Banana/plantain	Routine	In-house	Map/QTL	Pests, genepool
Maize	–	Available	Map/QTL	Genepool
Cowpea	–	In development	Map/QTL	Genepool
Soybean	–	Available	Available	–
Cocoa	Starting	–	Starting	Starting

Source: Rodomiro Ortiz (IITA, personal communication).

100 seed weight, cowpea mosaic virus, and bruchids were identified. DNA markers for *Striga* resistance in cowpea have also been determined.

In maize, AFLP fingerprinting of farmer unclassified landraces and various lines was accomplished. In the near future, DNA markers for nutrient enhancement (biofortification) nutritional genomics will start.

Diagnostic tools and risk assessment

In addition to the above, IITA has developed diagnostic tools based on ELISA and PCR for virus detection on plants. Also IITA has the capability to undertake environmental risk assessment involving genetically modified crops as evidenced by a gene flow analysis done in the cultivated cowpea and its wild relatives.

Crop networking and biotechnology

IITA hosts the maize network WECAMAN (West and Central African Maize Network) in the subregion currently stationed at the WARDA headquarters in Bouaké, Côte d'Ivoire. WECAMAN is also one of the CORAF/WECARD networks. The Network Coordinator is Dr Baffour Badu-Apraku. WECAMAN submitted a proposal (April 2002) to the subregional organization and got its endorsement (August 2002) on "Enhancing the biotechnology research capacity of NARS to develop stress resistant/tolerant maize germplasm in West and Central Africa". The proposal is worth about US\$1.5 million.

Capacity building

IITA is committed to capacity building in training and technology transfer to enhance the biotechnology research capability of the NARS. A detailed analysis of training in biotechnology at both postgraduate (MSc and PhD degrees) and specialist, short-training levels was done in the 2000 survey (Alhassan 2001). Six training associates and an MSc candidate were trained subsequent to the 2000 survey over the 2000–2001 period. Five of these were in tissue culture, while two, including MSc students, were in molecular biotechnology. IITA also assists in biosafety capacity building programs with national governments and various stakeholders. IITA continues to assist in the creation of awareness in biotechnology issues through workshops it holds periodically on the subject. IITA is currently playing a dominant role in the ongoing USAID effort to strengthen biotechnology capacity of Nigeria.

WARDA

The West Africa Rice Development Association is an autonomous intergovernmental association comprising 17 countries in the subregion. Its mission is to strengthen sub-Saharan Africa's capability for technology generation, technology transfer, and policy formulation so as to increase the sustainable productivity of rice-based cropping systems while conserving the natural resource base and contributing to the food security of poor rural and urban households.

Research

WARDA uses anther culture assisted by molecular characterization of rice genotypes. WARDa is not producing transgenic plants yet due to the absence of a biosafety framework in the Côte d'Ivoire. It is currently collaborating with advanced laboratories in the area. In anticipation of imminent work in transformation and the passage of the biosafety law in the Cote d'Ivoire, WARDa is completing its confinement facilities. Marker assisted selection is ongoing for traits like weediness and disease resistance. WARDa is currently working on the introgression of rice yellow mottle virus (RYMV) resistant genes into new cultivars. The following institutions collaborate with WARDa for rice biotechnology:

- Cornell University is assisting with research in determining the total genetic diversity of *Oryza glaberrima*.
- IRD (Montpellier) is assisting with DNA marker development for aided-breeding for RYMV.
- IRRI is assisting in developing markers for African rice gall midge selection.
- YAAS (Yunan Academy of Agricultural Science, China) is involved with the exchange of interspecific material that restores fertility to cytoplasmic male sterile lines. This is important for hybrid rice production, because this technology can tag sterility genes to overcome sterility problems.
- CIAT is involved with the exchange of interspecific lines.

Training

WARDa has a modest laboratory for training in anther culture and molecular biology. This training is supported by USAID for visiting fellows. Duration is six weeks per visit. The Rockefeller Foundation assists with biotechnology capacity building in West Africa through the sponsoring of candidates identified by WARDa for awards. Currently training is ongoing in the following institutions:

- Cornell University provides training for a PhD student from Côte d'Ivoire.
- East Anglia University, in association with John Innes Center, assists two PhD students; one from Nigeria doing molecular breeding for RYMV resistance and the other from Benin Republic working on nematode resistance through the tagging of genes for resistance.
- Louisiana State University trains a Nigerian student working on soil acidity tolerance in rice but with field work at WARDa.
- Natal University educates a Nigerian who will soon undertake biotechnology research with fieldwork in WARDa.
- Texas A & M Univ. instructs one Malian student, who is working on drought-tolerant, marker-assisted breeding, and another student from Côte d'Ivoire working on marker-assisted breeding for African gall midge.

The above candidates are supposed to go into their national programs on graduation. Le réseau Ouest et Centre Africain du riz (ROCARIZ), the rice regional network, assists NARS on marker-aided selection and anther culture in short-term (six-week) training. The network has so far trained two breeders: one from Togo and the other from Burkina

Faso. The Rockefeller Foundation assists WARDA by providing resources for coordinating biotech training, a highly commended donor initiative that should be emulated. When coupled with the improvement of laboratory infrastructure in the candidate's home country, a solid foundation for in-country research capability and subregional collaboration in biotechnology is laid out.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has the mission to "enhance the livelihoods of the poor through integrated genetic and natural resource management strategies". Its headquarters are in Patancheru (near Hyderabad, Andhra Pradesh, India) with the main stations for West and Central Africa in Niamey (Niger), also known at ICRISAT as their regional hub. A small team works mostly on sorghum in a station at Bamako (Mali) and one internationally recruited staff (IRS) at Kano (within IITA station) in Nigeria. ICRISAT mandate crops are three cereals, namely, sorghum, pearl millet, and finger millet and three legumes, namely, chickpea, pigeonpea, and groundnut. ICRISAT has six global themes, which are working on:

1. Harnessing biotechnology for the poor.
2. Crop management and utilization for food security and health.
3. Water, soil, and agrobiodiversity management for ecosystem health.
4. Sustainable seed supply systems for productivity.
5. Enhancing crop–livestock productivity and systems diversification.
6. Semi-arid tropics futures and development pathways.

The deliverables under the biotechnology global theme are the robust and cost-effective screening systems for indirect selection in plant breeding and for detection of contaminants; characterized genetic stocks for crop improvement and basic scientific research; and agronomically elite and transgenic breeding lines with stress resistance/tolerance and higher nutritive quality.

Staff and research

The ICRISAT station in Mali was visited in June 2002. The contact persons were Dr E. Weltzien-Rattunde, Dr Fred Rattunde (both sharing a sorghum breeder job), Dr Bonny Ntare (groundnut breeder, but likely to move to Niamey), and Dr Benoit Clerget (a sorghum ecophysiologist on secondment from CIRAD). The key mandate crop for this ICRISAT station is sorghum. There are no biotechnology labs or similar facilities at the ICRISAT station in Mali. For example, DNA characterization is done in India for this station. The research areas of sorghum which require molecular characterization or intervention are *Striga* resistance, drought tolerance, sorghum stover quality improvement for livestock, biofortification with micronutrients, and assessment of genetic diversity in sorghum. The latter is needed because the predominant Guinea race of sorghum is characterized by wide diversity and more precise characterization. For groundnut, marker assisted breeding is required in the following areas: drought tolerance, rosette virus resistance, and aflatoxin resistance. The peculiarity for groundnut seed production is that it has a high seed rate (80 kg/ha), and the crop is self-pollinated. Farmers will not need to purchase seeds yearly

as they can keep seeds for many years. Not many companies are willing to go into commercial groundnut seed production as a result. This observation has implications for the groundnut seed industry in West and Central Africa. CIRAD is collaborating with ICRISAT for work in Mali on sorghum. CIRAD will assist in the molecular characterization of sorghum biodiversity. A local molecular biology laboratory may be established in Mali, but pending this building, the characterization will be still done in India. A female molecular biologist was expected from CIRAD to start the characterization of sorghum landraces. A suggestion was made to link up with the applied molecular biology of the University of Mali for the characterization on sorghum.

ILRI

The International Livestock Research Institute (ILRI) has a mandate to improve the productivity of smallholder livestock and mixed, crop–livestock systems while protecting the natural resources that support these systems. The headquarters is in Nairobi (Kenya). ILRI keeps a small team in West and Central Africa through an office at the IITA headquarters in Ibadan, Nigeria. ILRI has very extensive infrastructure for biotechnology work at its ILRI laboratory in Nairobi (Kenya) devoted largely to diagnostic work in livestock and vaccine production. There is very little contact with West and Central Africa for biotechnology work. A few countries in the subregion have benefited from laboratory training at the Nairobi biotechnology laboratory and also participated in the groundbreaking research confirming the origin of African indigenous cattle breeds to be in Africa (Hanotte et al. 2002). The countries participating in that research only submitted blood samples and complained of the lack of any direct capacity building benefit associated with the exercise.

ARCT

The African Regional Center for Technology was established in 1977 as an intergovernmental organization under the aegis of the United Nations Economic Commission for Africa (UNECA) and the then Organization of African Unity (OAU) as a subregional development center (SRDC). Its headquarters is in Dakar (Senegal) and the Executive Director is Dr Ousmane Kane. The aim of ARTC is to become an efficient tool in triggering, strengthening, coordinating, and integrating national, subregional, and regional technological capacities and strategies of African states. Biotechnology focuses on postharvest processing, especially traditional food fermentation, and program coordination. Under a US\$500 000 grant from IFAD, ARTC is coordinating the agricultural activities of various agencies in West Africa namely, WARDA, CORAF/WECARD, le Comité permanent Inter-états pour la lutte contre la sécheresse dans le Sahel (CILSS), ECOWAS, and Union Économique et Monétaire Ouest-africaine (UEMOA) in the following areas:

- common agricultural policy coordination (UEMOA)
- market for agricultural products coordination (ECOWAS)
- Information systems coordination by Ministries of Agriculture (CORAF/WECARD)
- training and human resource development (HRD) coordination by CILSS in Ouagadougou
- environment and desertification coordination (ECOWAS).

The above IFAD support program allowed the holding of the roundtable conference on biotechnology in March 2002 in Dakar to define a future direction for biotechnology in the subregion. The idea behind this activity, following the coordinating role of ARCT, is to harmonize programs in the subregion and to avoid costly duplications.

UNU/INRA

The United Nations University/Institute for Natural Resources in Africa (UNU/INRA) was established in 1986 as Research and Training Center (RTC) of the United Nations University to catalyze the formation of human capital in science and technology for the effective conservation, management, and utilization of African natural resources. The headquarters is in Accra (Ghana). UNU/INRA does not operate like a traditional university. It has no regular students, no regular courses, and does not award degrees. UNU/INRA collaborates with existing universities to strengthen existing courses and develop new courses of short-term training programs for researchers and technologists relevant to the conservation of soil fertility and biodiversity conservation. A cardinal objective is to “develop the advanced skill/knowledge base for natural resources conservation and management in two ways: (1) by challenging current African scientists to conduct “basic” research, thereby bringing the grassroots knowledge of farmers and forest-dwellers to the laboratory and “high-tech” science arena, and (2) by focusing on education and training of young scientists in cutting-edge science.” In recognition of the role biotechnology can play for food security in the subregion, UNU/INRA has provided US\$65 000 to expand the physical facilities and modestly equip the tissue culture facility of the Botany Department of the University of Ghana. This revamped facility has since 1998 (and under UNU/INRA sponsorship of candidates) provided international training courses in tissue culture to many scientists and technicians in the subregion. The courses have been organized on a yearly basis except in 2001 when it skipped. This course is popular as attested to while doing the survey. Similar such courses in molecular biology and fermentation could be organized on a regular basis in the subregion. Senegal is planning a professional course in various areas of biotechnology.

Development investors

The development investors or donors active in the subregion for agricultural biotechnology are USAID, IAEA, DANIDA, EU, the Gatsby Charitable Foundation, African Development Bank, and the Rockefeller Foundation. USAID is currently funding at least 18 biotechnology projects in Africa, a third of which are in West Africa. A few are Pan African while a greater number are in Eastern and Southern Africa (Table 27). Nearly all the USAID projects in West Africa are handled through IITA. They are designed to build capacity in research and development, biosafety, or sensitization/priority setting (Josette Lewis, personal communication). The research and development capacity building is in marker-assisted breeding, molecular diagnostics, or genetic transformation. The current funding in West Africa by USAID covers the three broad areas of research and development capacity building, biosafety, and sensitization or priority setting (Table 27).

Table 27. USAID biotechnology activities in Africa.

Sector	Lead Institution	Subregion
R&D/scientific capacity		
Cocoa/tree crops	USDA + IITA	West/Pan Africa
Cassava	ILTAB through IITA	West Africa
Cowpea	UC Davis + IITA	West Africa
Rinderpest vaccine	UC Davis	East Africa
Papaya	Cornell	East Africa
Banana	IPGRI through INIBAP	East Africa
Heartwater vaccine	Univ. Florida	Southern Africa
Biofortification	IARC + US Univs.	Pan African
Biosafety		
Cowpea environment impacts	Purdue through IITA	West Africa
Maize environment impacts	ICIPE	East/Pan Africa
Southern Africa Regional biosafety	ABSP + South Africa	Southern
ASARECA regional biosafety plan	ABSP+ASARECA	East/Central
Sensitization/priority setting		
CORAF biotech research survey	CORAF+IITA	West
ASARECA priority setting	ABSP+ASARECA	East/Central
Economic impact assessment	IFPRI + Purdue Univ.	Pan African
Biotechnology information outreach	Tuskegee Univ.	Pan African
Public outreach in biotechnology	USDA + HBCUs	Southern/East, Nigeria, South Africa, Zambia, Kenya
Bilateral program assessments	ABSP + USAID Mission	Uganda

Source: Josette Lewis (USAID, personal communication).

DANIDA funding is mainly in the area of food fermentation. The EU, IAEA, Gatsby Charitable Foundation, and Rockefeller Foundation are into capacity building in research and development. Gatsby Charitable Foundation and IAEA activities cover mainly tissue culture work in bananas and plantain and some molecular characterization of these in the case of the Gatsby Charitable Foundation. Gatsby provided funds for molecular characterization of yams as well as the development of a linkage map. It is also providing funds for the development of the cowpea genome work at IITA. EU funding covers major institutional capacity building work in tissue culture and molecular characterization for diagnostic purposes or breeding such as the cowpea drought characterization work in CERAAS in Senegal and to support for tissue culture banana production through the INIBAP program of IPGRI. Rockefeller's assistance is largely in biosafety capacity building and in training. The assistance to WARDA for postgraduate training in molecular biology is unique among donors. Multilateral donor sources for biotechnology are usually components of large credit finances to countries, portions of which are earmarked for biotechnology as is the case in Ghana and Cameroon.

It appears there is not much overlap between the USAID biotechnology funded projects and those indicated for the other development investors nor indeed within USAID projects. This is because most projects funded by other donors are dealing mainly with tissue culture, while the USAID projects are at the more advanced marker assisted breeding and genetic transformation levels for research and development capacity. The postgraduate training support by the Rockefeller Foundation could have been integrated with the research and development funding support of USAID, but the Rockefeller support is in rice, a commodity not currently being supported for research and development by USAID. In view of the call for training support by the NARS, USAID is encouraged to incorporate postgraduate training fellowships into each of its research and development support projects. Such training should be done in collaboration with local institutions but with a provision for short-term training in advanced research institutes when the need for such training is identified. While more development investor support is required for research and development, it would seem that (as done by USAID and the Rockefeller Foundation) other development investors should also channel resources into biosafety capacity building and public awareness creation.

Emerging institutions to support CORAF/WECARD on biotechnology

CORAF/WECARD should monitor the following emerging institutions that could assist it in its capacity building efforts.

African Agency for Biotechnology (AAB)

AAB was created in 1992 by 16 African Ministers responsible for science and technology. It became functional in 1997 with the creation of its headquarters in Algiers. It has a Governing Council of member states at ministerial level, a scientific & technical committee, and a secretariat. The objectives are to:

- reinforce the national capacity of member countries in matters of biotechnology
- coordinate research and development programs in biotechnology
- encourage production, distribution, and commercialization of biotechnology products while ensuring their sustainable development and protection of the environment
- develop and harmonize the laws in bioethics, biosafety, intellectual property rights, and inventions.

AAB has financial problems and is currently not visible. It is expected that the African Development Bank will be its major donor. It proposes the establishment of an African Program for the Development of Commercial Biotechnology in which member countries will vie for funds for the execution of biotechnology projects at the point of commercialization.

African Agricultural Technology Foundation (AATF)

AATF will be inaugurated in early 2003. AATF is an African-led, public–private sector partnership set up to respond to the technology needs of resource-poor African farmers, nearly all of whom are smallholders. Such technologies may be nonpatented, public-sector owned, or be proprietary from private sector institutions. Patented technologies will be obtained free of royalty fees from willing private-sector technology owners for subleasing to research institutions for adaptation to local conditions as need be. The entire technology development and transfer chain from the initial product development to marketing will be addressed. The Rockefeller Foundation and USAID provided the start-up funds for the AATF. There is a Design Advisory Committee (DAC) comprising heads of African NARS, the Rockefeller Foundation, and other donors like USAID, private biotechnology companies in the OECD, African Seed Companies, DANIDA, and DfID. The headquarters is yet to be determined. The implementing Director is Dr Eugene Terry, former Director-General of WARDA.

Gaps and opportunities for intervention in biotechnology in West and Central Africa

The gaps and opportunities for biotechnology intervention can be discerned from the activities ongoing or planned in research and development, biopolicy, public awareness, and private-sector empowerment in biotechnology.

Research-for-development

The commodities on which research has been ongoing or planned as reported earlier in this report are summarized in Table 28.

The bulk of the research on roots and tubers, *Musa* spp., and tree crops is on mass propagation through tissue culture. The few endowed laboratories in the NARS do germplasm characterization on these crops and molecular diagnostics work on them. For cereals, the few NARS working in the area do germplasm molecular characterization. Fewer still work on markers for quantitative trait loci (QTL) identification to assist breeding and selection. For this, only four laboratories, namely, CRIG in Ghana, CNRA in the Côte d'Ivoire, and CERAAS in the Senegal—working in collaboration with UCAD-Faculty of Science, have the capacity. Thus, for any assistance to bridge the gap in biotechnology research, it would seem appropriate to gradually assist those laboratories at the tissue culture stage to move into germplasm characterization while those on characterization move to specific marker identification for a desirable gene or groups of genes. The three to four laboratories already doing QTL research can be given additional training support and equipment and linkage to an advanced laboratory in the subregion, e.g., IITA, to undertake biotechnology research to solve the intractable problems of resistance to the biotic and abiotic stresses. Crops with serious disease and pest problems currently being researched using conventional approaches, but which could benefit from genetic transformation, include cotton, cowpea, maize, sorghum, cassava, cocoyam, cocoa, and coconut. For some of these commodities,

Table 28. Commodities receiving biotechnology attention in West and Central Africa.

Commodity	Constraints
<i>Plants</i>	
Roots and tuber crops	Planting materials, diseases, germplasm characterization
Cassava (<i>Manihot esculenta</i>)	
Yams (<i>Dioscorea</i> spp.)	
Cocoyam (<i>Xanthosoma sagittifolium</i>)	
Sweetpotato (<i>Ipomea batatas</i>)	
Potato (<i>Solanum tuberosum</i>)	
Musa spp.	Planting material, diseases, germplasm characterization
Banana (<i>Musa</i> spp. AAA)	
Plantain (<i>Musa</i> spp. AAB)	
Cereals	Genepool characterization, <i>Striga</i> , drought, diseases, insects, other weeds.
Maize (<i>Zea mays</i>)	
Sorghum (<i>Sorghum bicolor</i>)	
Rice (<i>Oryza sativa</i>)	
Pearl millet (<i>Pennisetum glaucum</i>)	
Legumes	Genepool characterization, insects, drought.
Cowpea (<i>Vigna unguiculata</i>)	
Tree crops	Planting material, genepool characterization, insects, disease.
Oil Palm (<i>Elaes guineensis</i>)	
Coconut (<i>Cocos nucifera</i>)	
Cocoa (<i>Theobroma cacao</i>)	
Sheanut (<i>Vitellaria paradoxa</i>)	
Kola (<i>Cola acuminata</i>)	
Rubber (<i>Hevea brasiliensis</i>)	
Fiber crops	Insects, planting material.
Cotton (<i>Gossypium</i> spp.)	
Kenaf (<i>Hibiscus cannabinus</i>)	
Animals	Diagnostics, disease (vaccines), characterization
Cattle	
Sheep	
Goats	
Poultry	
Others	Isolation, characterization, and production of inocula (nitrogen fixation and food fermentation).
Microorganisms	

technology for transformation was developed elsewhere and only needs to be adapted to local conditions. Work on genetic transformation must be linked to the development and ability to implement biosafety guidelines. USAID or other development investor support for biotechnology where linked with an IARC or advanced laboratory should rapidly promote technology transfer in the critical areas to the NARS through the incorporation of postgraduate fellowships into such biotechnology projects. For tissue culture, the development of protocols may be problematic and time consuming. A couple of laboratories may be designated tissue culture elite laboratories to be equipped to undertake such exploratory protocol development for the use of the NARS.

The research programs in animal biotechnology ongoing or planned by the NARS of West and Central Africa could benefit from ILRI collaboration through training, collaborative research, the development and transfer of research protocols etc., in diagnostics, molecular characterization of livestock and poultry, and their linkage with breed improvement work and recombinant vaccine production. For instance, Mali wants assistance to help it develop a recombinant vaccine against contagious bovine pleuropneumonia (CBPP). Some collaborative proposal with ILRI to a donor for assisting Mali to develop this vaccine in its laboratories would be most desirable. The heartwater (cowdriosis) vaccine project for Southern Africa funded by USAID is of much interest to West and Central Africa. A means should be sought to enable the extension of this project to the subregion for testing its potency within the subregion and making modifications as need be. This testing should be in collaboration with the one being undertaken by CIRDES (Bobo Dioulasso, Burkina Faso) in collaboration with Guadeloupe. ILRI could assist in all these initiatives with development investor support.

The constraints identified for biotechnology research by the NARS (Table 18) lists training as a number one priority for the NARS. The initiative taken by the Rockefeller Foundation for postgraduate training through fellowships should be emulated but this should be modified to localize such training as much as possible in local universities and sharing of facilities for the training with local endowed research institutes with an opportunity for specialized training in advanced laboratories as needed. As earlier advised, all funded biotechnology research should have an in-built provision for a postgraduate training fellowship. Short, nondegree attachment training to researchers and technicians as offered by IITA should be encouraged, but where the NARS can offer such training, they should be encouraged to do so with IITA backstopping where necessary. Such an arrangement is ongoing between IITA and the Botany Department of the University of Ghana's subregional training in tissue culture. Apart from funding, a shortage of laboratory equipment repair technicians and spare parts was highly ranked as a constraint to biotechnology. USAID or other appropriate development investor should look into the possibility of sponsoring periodic, hands-on laboratory training in instrumentation with a mechanism for the facilitated acquisition of laboratory spare parts. The problem of laboratory equipment can be greatly minimized if NARS develop the capability to present good proposals to development investors for funding. Invariably, the approved

projects will have the equipment and consumables needed built into them. Most of the better-endowed laboratories in the subregion are equipped through this means. More in-country training in project proposal writing should be given with some of the more successful NARS scientists in the subregion acting as resource persons in addition to others that may be brought in from outside the region.

Biopolicy

The biopolicy issues discussed here relate to biotechnology policy, biosafety capacity building, and intellectual property capacity. Apart from Nigeria, none of the countries of the subregion has developed a biotechnology policy document to guide it in priority setting and identifying the institutional framework to promote biotechnology capacity. Development investor assistance is clearly needed in all these countries to do a needs assessment and to help establish the priority actions. Côte d'Ivoire has set up a body to undertake this while Mali organized a workshop in June 2002 to begin the process. The USAID mission in Mali and the Syngenta Foundation, which is active in this country, could give Mali the necessary assistance to formulate this policy and to be able to harmonize the institutional needs for biotechnology in the country. All biosafety capacity building measures should be accompanied by the needed strengthening of biotechnology capacity. Currently, an increasing number of governments in the subregion appear more concerned about biosafety issues than in building the necessary capacity to produce the biotechnology products for their citizenry guided by the biosafety protocols in place. In any case, without the biotechnology capacity, no effective risk assessment or management can be done. Any development investor or government initiative to address biosafety capacity should also develop biotechnology research and development capacity. Biosafety capacity gaps to be filled are identified in Table 21. Countries in the subregion are at different stages in developing their biosafety laws. This dictates the amount of help needed. Cameroon, Côte d'Ivoire, and Nigeria, which are advanced and at the point of legislation, will need help with implementation of the laws. A desirable scenario is for the countries to test their laws on a GM-technology they have developed as in the case with Kenya. Ghana will need assistance in holding various workshops and public debates on their draft framework document before proceeding to cabinet submission through the Ministry of Environment Science & Technology en route to parliament. Burkina Faso, Mali, and Senegal are at the point of either putting a drafting committee together (Mali and Senegal) or getting the committee to work (Burkina Faso). For these countries, initial public sensitization fora should be held as a committee is appointed to begin work. At all stages funding will be required to expedite action in the form of meetings, workshops, honoraria, and documentation, among others. Development investor support will be required to bring resource staff. An additional funding source is UNEP/GEF. As pointed elsewhere in this report, all countries qualify for the UNEP/GEF funds even though only Cameroon has ratified the protocol. Mali protocol has only the cabinet left on its way to Parliament whilst Ghana is at cabinet level. Biosafety training was the weakest in the region at the NARS level (Table 3). A concerted training effort should be in place to address this weak point.

Intellectual property

The knowledge base on intellectual property issues among the NARS was found to be low with less than 25% indicating familiarity with the subject (Table 17), but not as abysmal as biosafety. A number of in-country workshops stressing plant and animal products could be organized with World Intellectual Property Organization (WIPO) or African Regional Intellectual Property Organization (ARIPO) assistance and other development investor support. As for biosafety, an in-country training workshop organized periodically would be more effective than a subregional one to enable greater participation. As more people become familiar with the subject, local resource persons could be used to run subsequent courses.

Lessons from ASARECA biotechnology and biosafety regional framework development process

One of the terms of reference of the current CORAF/WECARD assignment is to develop a framework to assist in undertaking priority setting for biotechnology research and development from a regional perspective. ASARECA is undertaking a similar process and is more advanced in this regard than CORAF/WECARD. A study of the ASARECA planning process could facilitate the CORAF/WECARD approach to attaining a similar goal. Information on the ASARECA planning process was derived largely from consultations with Dr Josette Lewis of USAID in Washington and from the presentations at the just concluded ASARECA Biotechnology Initiative Stakeholders Meeting (17–19 June 2002) as well as personal briefings of the ASARECA Biotechnology Coordinator, Dr Christopher K. Ngichabe.

Since 1998, the ASARECA Committee of Directors (CD) sought assistance from development investors to commission a briefing paper to assess the potential opportunities to the region of a biotechnology and biosafety initiative under the ASARECA umbrella and to identify the strategies to develop the initiative. The study was funded by USAID and UNDP and was undertaken by ISNAR with the assistance of the Agricultural Biotechnology Support Program (ABSP) at Michigan State University. The terms of reference for the briefing document included the review and documentation of current and planned biotechnology activities in the region and ASARECA role in a regional program in biotechnology and biosafety. The report was also to recommend the setting up of a task force to study the outcome of the report. The consultant's report recommended an integrated approach to biotechnology and biosafety for consideration in addition to the current networks. A network-based planning meeting was recommended to identify the opportunity and the need to introduce and integrate biotechnology into the existing network programs. The research networks integrating biotechnology were to be prioritized. The funding implications for implementing and enforcing biosafety legislation were also considered. A working group was appointed to study the report for necessary action. A project coordinator was appointed to ensure the completion of tasks identified by the networks. The report

was duly submitted and at the September 1999 meeting of the ASARECA Committee of Directors, the Directors recommended the creation of a working group and process to develop a biotechnology and biosafety initiative. The need to adopt a regional approach was underscored by the fact that:

- Capacity of individual NARS to undertake independent biotechnology research is generally low given human resources and infrastructure limitations. Several NARS, however, are conducting biotechnology research in collaboration with advanced laboratories that could have regional impact if adapted and disseminated through ASARECA.
- IARCs are developing biotechnology research tools and genetically engineered crops that could also help address regional priorities and complement ongoing research under the ASARECA commodity networks if integrated into the ASARECA agenda.
- Given limited resources at both national and donor levels, it is unlikely that national programs will be able to launch significant biotechnology initiatives and thus regional cooperation and strategic partnerships with advanced research institutes could accelerate access by the region to biotechnology tools and applications.
- In the area of biosafety, only one country in the region currently has in place national biosafety regulations. In the absence of biosafety regulations, NARS will not have access to biotechnology applications such as genetically engineered crops or livestock vaccines.
- With the recently adopted Cartagena Protocol on Biosafety, countries will need to take steps to adopt biosafety systems that enable implementation of this agreement. NARS should play a key role in this process given that agricultural applications of biotechnology will be the most impacted by biosafety regimes. In addition, development of biosafety systems should incorporate related phytosanitary and technical expertise that is found among the NARS. A regional program that includes biosafety capacity building would better enable the NARS to participate in biosafety policy formulation.
- Biosafety requires a range of technical expertise including areas such as ecology, molecular biology, and plant and animal pathology, among others. Given that many countries in the East and Central Africa region will not have sufficient technical expertise at the national level, development of a system for regional cooperation on biosafety reviews would improve the rigor of biosafety regulations.
- Further, analogous to the current ASARECA initiative to harmonize and streamline seed regulations in the region, harmonization of biosafety regulations will improve regional dissemination of biotechnology derived crops and vaccines and reduce barriers to private-sector investment in these areas.

For these reasons, ASARECA launched a biotechnology and biosafety planning process for which additional support was sought. In January 2000, ASARECA held a consultative meeting with ISNAR, UNDP, and USAID to develop a detailed terms of reference for an ASARECA working group to steer the planning process. ASARECA CD adopted the terms of reference in February 2000. The Biotechnology Working Group held its first meeting

in September 2000 to review the terms and develop a consensus on the specific activities aiming to develop a proposal for a comprehensive program in biotechnology and biosafety by September of 2001. ASARECA was seeking at the same time multidonor support for the implementation of this proposed program in 2001/2002.

Objectives

The objectives for the program development phase were to lay the foundation for and then examine specific objectives and strategies for an ASARECA program to integrate biotechnology into regional research activities and to develop a regional approach to biosafety regulations. Specifically, the objectives were to:

- Hold a broad dialog among regional stakeholders in the research and policy community to sensitize constituents to the issues and build consensus towards a program in biotechnology and biosafety.
- Develop a vision for the role of ASARECA in facilitating the application of biotechnology and development of biosafety regulatory systems.
- Identify specific opportunities for research, adaptation of existing technologies, or technology transfer that will lead to the application of biotechnology in addressing priority constraints in the region. This includes identification of priorities, opportunities to adapt existing research in the international community, and identification of strategic partnerships with advanced institutions, both public and private.
- Determine the mechanism and structure for a regional biotechnology initiative under ASARECA.
- Develop consensus on the specific goals, approach, and administration of regional biosafety regulatory development.
- Determine the mechanism and structure for a regional biosafety initiative under ASARECA.
- Develop work plans, budget, and a full proposal for implementation of biotechnology and biosafety programs for submission to donors.

Specific activities

As mentioned above, the ASARECA Secretariat, with direction from the CD, convened the Biotechnology Working Group to implement the program development plan. This working group met in September 2000 to refine the following agenda of activities.

1. Working group—10 members representing each of the NARS, two to three outside technical experts, and two ex-officio members including the ASARECA Secretariat and a Biotechnology Coordinator. The working group elected a chair from among its NARS representatives. This group plans, oversees the implementation of, and makes strategic decisions related to the development of the regional program. The working group should meet several times over the course of the year to achieve its work.
2. Biotechnology coordinator—to assist the ASARECA Secretariat in administrative support of the working group, a biotechnology coordinator was hired for the one-year planning phase after six months. The coordinator takes primary responsibility

in executing the activities planned by the working group such as commissioning background papers, planning regional workshops, summarizing working group meetings, and ultimately, writing the program proposal to come out of this planning phase.

3. Background paper on biotechnology options—this document assisted the working group to identify priority opportunities to research, adaptation of existing technology, and technology transfer. To do so, it surveyed and synthesized into priority opportunities:
 - national agricultural research priorities
 - current ASARECA regional research priorities
 - existing research in the international community with applicability to ASARECA (ABSP report on this already provided)
 - potential benefits and impact of biotechnology to agricultural systems in the region drawing from studies and data that might be available elsewhere biotechnology is being deployed.

Details of activities of the working group and the outcome of the ASARECA biotechnology workshop are presented in Appendix 3.

Subregional framework for biotechnology and biosafety in West and Central Africa

The biotechnology and biosafety planning process developed for ASARECA member countries is highly relevant to the CORAF/WECARD subregion and shall be adopted with modifications as necessary. However armed with prior knowledge of ASARECA procedures and having executed the key tasks already, CORAF/WECARD can make more rapid progress in the planning process. The tasks completed and herein reported are:

- an inventory of ongoing and planned research projects
- an inventory of available research laboratory infrastructure and manpower
- identification of commodities and themes being researched on
- identification of constraints to biotechnology
- status of biosafety legislation and manpower.

Key events in the CORAF/WECARD evolution and the management structure create an enabling environment for the development of a biotechnology and biosafety subregional mechanism. CORAF/WECARD in its 2000 Strategic Plan identified its priority commodities and themes for research. These are the commodities and themes that must benefit from biotechnology intervention. The commodities being researched on with modern biotechnology tools are all within the priority listing by CORAF/WECARD in its strategic plan. CORAF/WECARD has defined a comprehensive subregional research network management mechanism that has been tried, tested, and refined over the 15 years of existence. These are the base centers, poles, and networks that are as defined below.

Base center. A base center possesses special abilities to undertake research and it is based in a national system. Scientists from other countries can work there. Here capacity does not exist in the partner countries. The base center management is autonomous. It can get funds from donors direct or through CORAF. CERAAS is a base center in Thies, Senegal, so is CIRDES in Bobo Dioulasso, Burkina Faso.

Pole. Countries in a pole (usually 2–3) have similar capacities but are coordinated by one of the NARS. Each partner country works on a specific theme within the global theme e.g., for irrigation, each component in a pole leads research in a specific area. For instance, Mali leads research on land degradation while Senegal leads on grain production intensification. Pole management is also autonomous. CORAF is involved in the search and negotiation for funds for the poles, base centers, and networks. Their managements are autonomous.

Networks. This is a linkage of many countries working on an identical commodity or theme. All the 21 member CORAF countries can belong to the same network, e.g., ROCARIZ for rice networking or WECAMAN for maize networking. Networks like the base centers and poles, have steering committees that are management committees but the general assembly determines the orientation of the network. The steering committee is responsible for this in the base center and pole.

Suggested criteria for the regional framework on biotechnology

Currently, CORAF/WECARD has 13 research networks covering various commodities and themes, two poles (irrigated systems based in Mali and the development of the savannas based in Chad) and three base centers (CERAAS for drought, CIRDES for livestock, and ITC for trypanotolerant cattle). The base centers are currently integrating molecular tools into their work at DNA characterization level or the use for diagnostics. The integration of biotechnology into network programs has been planned with WECAMAN. A proposal has been submitted by the network to CORAF/WECARD (for endorsement) to build capacity for research in developing *Striga* and drought tolerant maize germplasm. DNA markers are to be identified for these characters and used to assist breeding and selection. Two NARS laboratories (through a competitive bidding arrangement) will be selected to equip and train all in the networks on the understanding and use of molecular techniques in maize breeding. Outputs of the selected laboratories will be available to the other NARS in the network for breeding programs. IITA will backstop the laboratories in biotechnology activities.

Network prioritization for selection

There is the need to select about four research networks for special support to integrate biotechnology activities. The goal for biotechnology intervention should be well defined with the necessary human resource development need incorporated into the research programs. These laboratories, most of which are currently crop-based, should be assisted

to carry out their molecular biology work to at least marker assisted breeding and selection stage. A special effort should be made to have a laboratory with a livestock diagnostic or vaccine production capacity to be represented in the laboratories that may be selected. An initiative for veterinary diagnostics is planned for Nigerian National Veterinary Research Institute (NVRI) under a special capacity building partnership with USAID. This laboratory is currently receiving donor assistance from the French Government and UNESCO. A soil fertility initiative with the Microbiology/IRD/UCAD laboratory at Senegal as hub should be considered. Some other suggestions:

- For the three laboratories (CERAAS, CRIG, CNRA) working on QTL mapping using DNA markers, assistance can be given to fine-tune this research and undertake genetic transformation when needed. Such laboratories and any others that might emerge through national effort (like the one being developed in Nigeria), could serve as base centers with special subregional tasks designated by CORAF/WECARD. Fellowships could be given to scientists to work in such laboratories for stated time periods. This is currently ongoing at the CERAAS laboratory in Thies and the Soil Microbiology/IRD/UCAD laboratory in Dakar (Senegal). Both Côte d'Ivoire and Nigeria are planning similar initiatives. CNRA in Côte d'Ivoire is setting up a facility to be able to take 40 visiting scientists at any one time.
- All biotechnology support projects with a plant or animal improvement focus should be nested within a breeding program. Biotechnology should be seen as completing the existing breeding program.
- Where selected laboratories are handling commodities for genetic enhancement, parallel laboratory support should be given to address the molecular diagnostic need of the commodity.
- As much as possible, biotechnology support for commodities should be holistic to consider both the primary product development as well as downstream processing (fermentation, preservation generally, etc).
- Ultimately the constant availability of clean drinking water, electricity, and critical manpower should determine the placement of a laboratory of excellence.

Outsourcing of biotechnology services

There is the need to consider the outsourcing of certain molecular laboratory services like sequencing and primer production from a laboratory with a DNA synthesizer. It is also possible to outsource molecular characterization work and gene mapping to a more endowed laboratory in the subregion.

Management of biotechnology nodes/networks

The existing CORAF/WECARD management criteria with coordinators, steering committees, technical committees, independence, accountability, and the like should be the criteria to guide the management of the chosen network center.

Sustainability criteria for biotechnology

The need for laboratory chemicals, equipment manufacture, and repair locally should be examined. Common biochemical reagents like enzymes, gels, and equipment including

glassware that can be produced locally should be so produced. The necessary training should be given to accomplish this and private agencies sensitized to go into commercial production and servicing of equipment for the biotechnology industry. The Sheda Science and Technology Complex (SHESTCO) in Abuja (Nigeria) has built a laboratory equipment production workshop to fabricate scientific equipment. In Ghana, the CSIR-Institute of Industrial Research has a scientific instrumentation unit that produces laboratory glassware but does not receive adequate patronage. An equivalent set up in the subregion is needed to produce key reagents locally. The biotechnology laboratory at the Institute of Food Technology (ITA) in Dakar (Senegal) is fabricating fermentation equipment for the local industry and has trained local artisans to fabricate them. These examples are worth emulating and supporting. Poor marketing skills have hampered the patronage of these fabrication centers.

Training

Training is to be a component of network activity and should cover both short-term training and long-term postgraduate training. The budget for network research activities should have the training component built into it.

Other views on centers of excellence

The views of the NARS and various stakeholders was sought on this subject but the response was few and varied. A few endorsed the creation of centers of excellence but they did not indicate what form it should take. It was suggested that national capacities needed strengthening first. A virtual biotechnology center was suggested by one NARS to have only an information dissemination role. Under this arrangement, any emerging center could undertake specialized biotechnology activities but these would be coordinated and disseminated electronically by an identified institution in the subregion. Others, namely, WARDA and IITA, suggested the creation of a genomics laboratory for the whole of Africa. Details of the views are also in Appendix 1.

Harmonization of USAID support for national laboratories with subregional capacity building goals

USAID support for national laboratories is in order since a strong NARS capacity is required for a viable subregional framework. It is however suggested that USAID support should gradually emphasize the chosen network centers within the NARS. This will ensure that capacity is built within the NARS while serving a regional course.

Criteria for the regional framework on biosafety

An effective national biosafety framework is a necessary prerequisite for the successful introduction and implementation of a subregional framework. The national frameworks and guidelines are part and parcel of the biosafety legislations. So far none of the countries has its legislation in place though it is advanced in the case of Cameroon, Côte d'Ivoire, and Nigeria as earlier pointed out. The biosafety framework proposed for the ASARECA

subregion is generic and could be adopted by CORAF/WECARD. The framework earlier reviewed in this report considers the biosafety review process and administration from the country to the subregional, the regional (African Union), and to the global (Cartagena Protocol) level. This generic framework is presented in a very readable format in a recently published FAO report (Kitch et al. 2002). The trade-related aspects of the subregional framework proposed for the ASARECA region appears to be missing and it is proposed for further consideration by CORAF/WECARD. The national plant quarantine or phytosanitary agencies are those mandated by law to regulate movement of plant material in and out of countries. The guidelines for their operation are drawn from the Inter-African Phytosanitary Council (IAPC), which is mandated by the African Union (African Union) and based currently in Yaoundé (Cameroon). IAPC in turn draws its guidelines from the global body, the International Plant Protection Convention (IPPC) whose guidelines are harmonized with those of the World Trade Organization–Sanitary and Phytosanitary Measures (WTO–SPS) (FAO 1997). The WTO relates to the Convention on Biological Diversity (CBD) and the Cartagena Protocol. For the purpose of subregional trade, it is necessary to bring the agencies that regulate subregional movement of plant material into the CORAF/WECARD discussion on the harmonization of biosafety issues in the subregion. This course of action is further backed by the following observations made during the course of collecting information for this report:

- In Nigeria, the National Plant Quarantine Service (NPQS) currently uses tissue culture where appropriate to screen imported vegetatively propagated plant material. Some of the imports come in as tissue culture material. There are plans to use more sophisticated biotechnology tools in the future to assist plant quarantine work.
- In Mali, concern was raised about outmoded plant quarantine practices inhibiting the free movement of seed material. Subsequent discussions with experts in plant health management at IITA reveal that the situation in Mali is traceable to the presence of ill-equipped and poorly trained plant quarantine officers on modern plant diagnostic procedures. This situation is not unique to Mali but is widespread in the subregion. IITA has drawn a plan to address it but has not got the necessary development investor support yet to undertake the task. Perhaps this is the time to revisit the IITA proposal.

To jump-start the application of biosafety procedures in countries that do not have the legislation, it is proposed (Kitch et al. 2002) that an interim framework be implemented using biosafety guidelines and the existing permit system for approvals such as a quarantine law. This would be undertaken while the legislation for the final framework is being developed. This approach is worth adopting by the respective countries.

The final recommendation proposed for the biosafety framework for the subregion is:

- Adopting the generic framework proposed for the ASARECA subregion.
- Harmonizing the biosafety framework with those of the IAPC and national plant quarantine services.
- Initiating a training program on biosafety administration procedures.
- Assisting countries without biosafety frameworks and legislation to make the necessary advances on these.

- Harmonizing country frameworks and establishing a subregional clearing house mechanism for biosafety.
- Initiating a training program and retooling quarantine officials in the subregion for an efficient sanitary and phytosanitary service.
- Interim implementation of the framework under an existing plant regulatory act while the legislation is being developed.

Public awareness

Public awareness is a key factor in promoting the necessary buy-in for biotechnology. A series of awareness creation seminars and a very proactive attitude to the media by the NARS and governmental agencies would seem appropriate. The media will have to be assisted through contributing feature articles, organizing special biotechnology and biosafety workshops, sponsoring programs on radio and television, and writing texts of documentaries for filming by the media. It may be necessary to sponsor such documentaries through cash payment or provision of equipment. NGOs that play an advocacy role for biotechnology should be encouraged through sponsorship of their activities. NARS active in biotechnology should organize periodic tours for high school children to their laboratories to sensitize them and demystify biotechnology. Farmer organizations should also benefit from such public enlightenment tours.

IPR issues

There is a dearth of knowledge on intellectual property rights issues by the NARS in the subregion, especially as this relates to plant products and technologies. Periodic national and subregional workshops should be held on the subject for the benefit of the NARS. Issues related to benefit sharing should be a component part of the training workshop. Resource staff from relevant international organizations like WIPO and desk officers from agencies implementing IPR issues can be used in the training programs.

CORAF/WECARD role in the subregional framework

The CORAF/WECARD role in the subregional framework for biotechnology may be summarized as follows:

- training coordination
- assisting countries to develop their biosafety frameworks
- assisting countries to develop their biotechnology policies
- facilitating through sourcing funds for biotechnology and biosafety activities
- running competitive grant schemes
- playing the traditional monitoring role
- information dissemination
- advocacy.

In view of the low subregional awareness of CORAF/WECARD activities revealed by the survey, special assistance to strengthen its capacity in the area is needed.

CORAF working group and stakeholders' workshop

It is expected that CORAF/WECARD will receive this report and appoint a working group to study this report and use it as a basis for a stakeholders workshop to develop the subregional framework for biotechnology and biosafety. The working group will play an active role assisted by a coordinator (to be recruited) and IITA (as the backstopping agency) in mounting the workshop. The coordinator will ensure that follow-up actions are taken. The working group, as with ASARECA, will be responsible for overseeing the program planning, its implementation, and the crucial decisions related to the establishment of the subregional biotechnology and biosafety program.

Working group composition

There are 21 CORAF/WECARD countries. It would have been desirable if each country could be represented on the working group but this would be unwieldy. It is therefore proposed that the working group be comprised of a representative from each of the seven survey countries and a random selection of five from the remainder to make a 12-country representation. In addition, there should be three technical experts including one from IITA, a representative of the CORAF/WECARD Secretariat, and a CORAF/WECARD appointed coordinator. This makes a total 17. To help the group in deliberating on specialized issues, it shall have the powers to co-opt. A one-year planning phase is envisaged necessitating the hiring of a program coordinator during the one-year planning phase on a full time basis. Given the vastness of the subregion and the fact that the majority could not be surveyed in the present assignment, additional contacts may be necessary during the planning process to bring all fully on board. The program coordinator will execute all the activities of the planning process including the collation of reports, commissioning of expert assignments, and the final proposal emanating from all the working group deliberations. A three-day, broad-based stakeholders' workshop is proposed to undertake the following:

- receive the working group reaction to the coordinator report and expectations for a subregional initiative on biotechnology and biosafety
- determine the research and development priorities for a subregional program on biotechnology and biosafety
- define the subregional framework for biotechnology and biosafety
- establish the quantum and nature of support needed to execute the framework
- assess the governance structure and role of CORAF/WECARD in the subregional framework
- discuss any other matter relevant to the sustainable implementation of the developed subregional framework.

Proposed stakeholders to be invited to the subregional forum

About 100 participants should attend drawn from the 17 working group (WG) members, 28 CORAF/WECARD country representatives (other than those in WG), one from the CORAF/WECARD Secretariat, three USAID officers, three invited resource staff who can be invited to give talks on issues during the plenary session, six officers from other

development investors (e.g., the Rockefeller Foundation, African Development Bank, DANIDA, EU, Netherlands, SIDA, CIDA, IDRC, and DfID, among others), three staff from UNDP, FAO, ECA, FARA, African Union reps. (STRC, IAPC), four from CGIAR Centers other than IITA operating on biotechnology in or for the subregion (e.g., WARDA, ILRI, ICRISAT), IITA staff (who could participate actively in the organizing committee as needed), and the private sector through seed company representatives and those of the West African Seed Network (WASNET). Others are representatives of laboratory equipment importers/manufacturers and chemists/chemical engineers, media representatives (and not only from hosting country of workshop), NGOs, farmer groups, national plant quarantine officers, biotech development partners (AATF, ARCT, AAB), and a Patent Attorney/Registrar General representative. It is proposed that this and subsequent workshops and WG meetings be held at IITA headquarters in Ibadan. Alternatively, the workshops can be held at the IITA in Ibadan while WG meetings are held at the CORAF/WECARD Secretariat in Dakar (Senegal).

Discussion groups proposed for the subregional forum

The suggested discussion groups are:

Group 1. Crops

Group 2. Livestock

Group 3. Microbiology (soil and food fermentation)

Group 4. Policy, biosafety, and IP

Group 5. Governance, finance, and management of CORAF/WECARD Initiative

Group 6. Public awareness and agrobusiness

Group 7. Sustainability issues: equipment and laboratory reagents manufacture.

Suggested terms of reference for discussion groups

This shall incorporate the broad terms of reference for the WG as well as the terms for the ASARECA workshop as appropriate. The three discussion groups (one each for crops, livestock, and microbiology) will:

- Comment on the priorities for research and development of the crops sector and make any improvements necessary. This may include drawing a list of priority commodities and themes with constraints and interventions.
- Discuss on the working group's subregional framework for biotechnology and biosafety and make the necessary amendments.
- Assess the capacity building needs submitted by the working group and make the necessary recommendations.
- Suggest possible pilot research projects and transfer modalities to the private sector.
- Recommend effective linkage with various stakeholders.
- Determine any other matter relevant to the sustainable implementation of the outcome of your group's deliberations and suggest the next steps.

The discussion group on policy, biosafety, and IPR will:

- Comment on the goals and framework for biosafety presented.

- Suggest ways for effective harmonization of biosafety guidelines with phytosanitary regulations.
- Discuss the seriousness of the challenges facing the NARS on IPR issues and how these may be overcome.
- Recommend the steps to attain subregional harmony on biosafety.
- Determine any other matter relevant to the sustainable implementation of the outcome of your group's deliberations and suggest the next steps.

The discussion group on governance and finance will make recommendations on:

- Mechanisms for implementing the biotechnology and biosafety initiative especially with regard to the institutional arrangements and structures at the national and subregional level.
- Management of the biotechnology and biosafety initiative and the implications for coordination and assistance of the Secretariat.
- Strategic alliances with IARCs, the private sector, advanced research laboratories, and universities in the subregion and outside.
- Governance structure including a steering committee, external evaluation, and impact assessment and monitoring.
- Finance and potential funding sources.
- Action plan and time frame for implementation.

The discussion group on public awareness and agrobusiness will deal with:

- The general plan of action for awareness creation.
- Empowerment of the media to educate and inform the public on issues of biotechnology and biosafety.
- Stakeholder alliances for public awareness creation on biotechnology and biosafety.
- Possible areas of investment in agricultural biotechnology and how to promote private sector investment in the area.
- Market channels for agricultural–biotechnology export products and how to meet market challenges.
- Building the local seed industry capacity for linkage with seed improvement sources locally and abroad for technologies and products.
- Determine any other matter relevant to the sustainable implementation of the outcome of the group's deliberations and suggest the next steps.

The working group on sustainability issues (for equipment and laboratory reagents manufacture) will:

- List the items of equipment including glassware that can be manufactured locally.
- Determine from the reagent list supplied list those can be produced locally.
- Survey the constraints of the science laboratory equipment manufacturing sector and suggest how they may be solved.
- Determine the constraints of the chemical manufacturing sector and suggest means of overcoming them.
- Establish how product quality and price competitiveness can be assured.
- Discuss any other matter relevant to the sustainable implementation of the outcome of the group's deliberations and suggest the next steps.

Budget

This needs input from CORAF/WECARD and development investor(s), e.g., USAID, if above suggestions are accepted.

Time frame for the planning process

A one-year planning process is adopted as for ASARECA. The time frame activities are modified as necessary to suit CORAF/WECARD. A tentative time frame is proposed below.

Nov 2002–March 2003

- Submission of report to CORAF/WECARD and USAID (1–10 Nov).
- CORAF/WECARD discusses budget and time frame with USAID and seeks approval to appoint coordinator and to proceed. Appoints working group according to suggested guideline or modification as appropriate and distributes report to the working group (1–15 Dec).
- First meeting of working group (15–20 Jan) to review terms of reference (TOR) and prepare detailed work plan.
- Discuss the need for and prepare TOR for commissioned background papers in biotechnology, biosafety, IPR, and sanitary phytosanitary measures (SPS).
- Commission background papers (biotech, biosafety, IPR, and SPS).
- Brief CORAF/WECARD Committee of Directors (CD) on progress of program planning at (15–20 Mar).

April–June 2003

- Second working group meeting to review biotech, biosafety, IPR, and SPS background papers and develop first workshop agenda (April 2003).
- Share workshop agenda with key stakeholders (network directors) for comment (April 2003).
- Biotechnology/biosafety workshop (May 2003).
- Third working group meeting immediately following workshop to synthesize workshop outcomes (June 2003).
- Discuss the need for and commission an identified background paper for second biotechnology and biosafety workshop.

July–Sept 2003

- Fourth working group meeting to review commissioned paper and develop second workshop agenda (July 2003). Notification for second biotech/biosafety workshop issued for Aug 2003.
- Second biotechnology/biosafety workshop (Sept 2003).
- Fifth working group meeting immediately following workshop to synthesize workshop outcomes (Sept 2003).

Oct–Dec 2003

- Coordinator initiates preparation of biotechnology/biosafety proposal(s) (Oct 2003).
- Coordinator with review of WG develops agenda for final wrap-up workshop (first week Oct 2003).
- Final workshop to address remaining issues and ensure consensus on proposal(s) priorities and approach (Nov 2003).
- Coordinator submits draft of proposal(s) to working group for review (Dec 2003).

Jan–March 2004

- Sixth and final meeting of working group to finalize proposal(s) and discuss with key stakeholders (Jan 2004).
- Coordinator finalizes proposal(s) and submits to CORAF/WECARD Secretariat (Feb.2004).

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Acronyms and abbreviations

AAB	Agence africaine de biotechnologie/African Agency for Biotechnology
ABSP	Agricultural Biotechnology for Sustainable Productivity
ARIS	advanced research institutes
ARO	agricultural research organizations
ASARECA	Association for Strengthening Agricultural Research in Eastern and Southern Africa
ATRIP	Agricultural Trade and Investment Program
BIOEARN	East Africa Regional Biotechnology Programme and Research Network
BNARI	Biotechnology and Nuclear Research Institute
CAMBIA	Centre for the Application of Molecular Biology to International Agriculture
CBEN	Centre de biotechnologie/ Ecole normale
CERAAS	Centre d'étude régional pour l'amélioration d'adaptation à la sécheresse
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CNRA	Centre national de recherche agronomique
CORAF	Conférence des responsables africains et français de la recherche agronomique
CRBP	Centre de recherches régionales sur bananiers et plantains
CRIG	Cocoa Research Institute of Ghana
CRIN	Cocoa Research Institute of Nigeria
CSIR	Council for Scientific and Industrial Research
CSIR-CRI	Crops Research Institute
CSIR-FRI	Food Research Institute
CSIR-SRI	Soil Research Institute
CSIR-STEPRI	Science and Technology Policy Research Institute
CSIR-WRI	Water Research Institute
DANIDA	Danish International Development Agency
DFID	Department for International Development
DGIS	Directorate General for International Cooperation (translated)
DNA	deoxyribonucleic acid
ECA	Economic Commission for Africa
ECOWAS	Economic Community of West African States
EMBL	European Molecular Biology Laboratory
FAO	Food and Agriculture Organization of the United Nations
GAEC	Ghana Atomic Energy Commission
GMO	genetically modified organism
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IARC	international agricultural research center
IAR&T	Institute of Agricultural Research and Training
IBS	Intermediate Biotechnology Service
ICGEB	International Centre for Genetic Engineering and Biotechnology
IDRC	International Development Research Centre
IFA	international funding agencies

IFPRI	International Food Policy Research Institute
ILCA	International Livestock Research Institute for Africa
IITA	International Institute of Tropical Agriculture
ILRAD	International Laboratory for Research on Animal Diseases
ILRI	International Livestock Research Institute
INIBAP	International Network for the Improvement of Banana and Plantain
IRA	Institute of Agronomic Research (now IRAD)
IRAD	Institute of Agricultural Research for Development
IRAD–CRBP	Centre de recherches régionales sur bananiers et plantains
IRD	Institut de recherches pour le développement
IREN	Institut de recherche sur les énergies nouvelles
ISAAA	International Service for the Acquisition of Agricultural Biotechnology Applications
ISNAR	International Service for National Agricultural Research
ISRA	Institut Sénégalais de recherches agricoles
ISRA/URCIV	Unité de recherches de culture en vitro
ISRA/LNERV	Laboratoire national d'élevage et de recherches vétérinaires
KARI	Kenyan Agricultural Research Institute
MIRCEN	Microbiology Resources Research Center (translated)
MOFA–VSD	Ministry of Food and Agriculture, Veterinary Services Department
MSU	Michigan State University
NACGRAB	National Centre for Genetic Resources and Biotechnology
NARS	national agricultural research systems
NAU	Nnamdi Azikiwe University
NIFOR	Nigeria Institute for Oil Palm Research
NIHORT	Nigerian Institute of Horticulture
NRCRI	National Root Crops Research Institute
NVRI	National Veterinary Research Institute
PQS	Plant Quarantine Service
RCSA	Regional Centre for Southern Africa
ROTREP	Root and Tuber Research Project
SADC	Southern African Development Community
SIDA	Swedish International Development Agency
SIRDC	Scientific and Industrial Research and Development Centre
UCAD	Université Cheik Anta Diop
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural Organization
UNIJOS	University of Jos
UNN	University of Nigeria, Nsukka
UPOV	International Union for the Protection of New Varieties
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WARDA	West Africa Rice Development Association
WECARD	West African Council for Agricultural Research and Development
WTO	World Trade Organization

Appendices

Questionnaires used in the survey

Appendix 1a. Agrobiotechnology application survey—NARS/ CORAF affiliate institutions.

1. Country
2. Institution
3. Contact person
4. Designation
5. Address
6. Fax
7. Phone
8. E-mail
9. Website
10. Date
11. List of priority research areas/topics and stage of completion (*see attached table*)
12. Biotechnology tools in use (*see attached table*)
13. Biotechnology projects (*see attached table*)
14. Availability of functional biotechnology laboratory

(Tick)

Laboratory	Yes	No
Tissue Culture	<input type="checkbox"/>	<input type="checkbox"/>
Molecular Biology	<input type="checkbox"/>	<input type="checkbox"/>
Fermentation	<input type="checkbox"/>	<input type="checkbox"/>

15. Number of biotechnology/biosafety trained personnel

Field	Technician	Graduate	Total
Biotechnology	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biosafety	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16. Status of biosafety law (*see attached table*)
17. Ability to implement law at institution
18. Suggested regional framework for biotechnology and biosafety application including biotechnology priority setting
19. Constraints for biotechnology and biosafety application
20. Degree of involvement in CORAF/WE CARD activities (*see attached table*)
21. Intellectual property rights (IPR) awareness (availability of patent office, protection procedures, sourcing patented technology, germplasm protection, etc)
22. Ability to conduct technology impact assessment studies
23. General constraints to biotechnology and biosafety application

Appendix 1b. Agrobiotechnology application survey of government ministries/nonresearch agencies

1. Country
2. Ministry/Agency
3. Contact person
4. Designation
5. Address
6. Fax
7. Phone
8. E-mail
9. Website
10. Date
11. Awareness of and commitment to biotechnology application/promotion
12. Nature of commitment
13. Availability of a national biotechnology strategy and action plan
14. If Yes, list priority areas
15. Status of biosafety law (*see attached*)
16. Ability to implement law
17. Suggested regional framework for biotechnology and biosafety application
18. Status of action on Cartagena Protocol on biosafety
19. Number of persons in establishment working on biotechnology/biosafety issues
20. Level of training of personnel in biopolicy
21. Donor assisted projects in biotechnology/biosafety (indicate project type, donor source, level of support, support years, etc.)
22. General constraints for biotechnology and biosafety

**Appendix 1c. Agrobiotechnology application survey—
environment focused NGOs.**

1. Country
2. Name of NGO
3. Contact person
4. Designation
5. Address
6. Fax
7. Phone
8. E-mail
9. Website
10. Date
11. Nature of awareness for biotechnology
12. Impression on biotechnology products from agriculture
13. Awareness of biosafety
14. Biosafety monitoring capacity
15. Available trained personnel in biosafety
16. Willingness to train in biosafety
17. Willingness to recruit personnel with biosafety training
18. Regional/international collaboration existing or envisaged in biosafety

Appendix 1d. Press interview for public awareness creation.

1. Country
2. Name of paper or radio
3. Name of respondent and status in organization
4. Address
5. Telephone
6. E-mail
7. Website
8. Current ownership of press house (whether public or private)
9. Current level of circulation or reach of paper or radio
10. Availability of science correspondent (Yes or No)
11. If No, any plans to recruit one in the near future (Yes or No)
12. Frequency of reporting on science matters in general (*Please tick*)

Frequency	Yes	No
Daily		
Weekly		
Fortnightly		
Monthly		
Occasionally		
Rarely		
Never		
Other (Specify)		

13. Availability of program for farming community (Yes or No)
14. If yes, state frequency of reporting
15. Availability of program for environment and health including biodiversity
16. Do you understand the terms biotechnology, biodiversity, and biosafety?
17. If Yes, state your understanding of them briefly
18. What is the position of your paper/radio on biotechnology products (positive, negative or no fixed position)
19. Give reasons for your position
20. Public awareness creation initiatives now or planned
21. General constraints and suggestions for more effective role in science and biotechnology public education

Attached tables

11. List of priority research.

Title	Biotechnology (tick)		CORAF involvement (tick)		Network (list)	Stage of completion				Other
	In use	Planned	Yes	No		Ongoing	Finished	Technology transferred	Commercialized	

Etc.

12. Biotechnology tools in use.

Commodity/theme	Tool (please tick)							Other (list)
	Tissue culture	DNA characterization/fingerprint	Genetic marker (selection)	Genetic markers (introgression)	Recombinant DNA genetic engineering	Monoclonal antibody	Microbial fermentation	

Etc.

13. Biotechnology projects.

Commodity/theme	Problem under study	Network involved	Biotechnology product desired	Stage of development	Sponsoring agency

Etc.

16. Status of biosafety law.

Status of enactment (Yes or No)	Status of enforcement (Yes or No)	Focal point (ministry)	Competent authority (list)

Etc.

20. Degree of involvement in CORAF/WECARD activities.

Attendance of meetings	Research network (Yes or No)	List network where applicable	Regular information from CORAF (Yes or No)	Occasional information from CORAF (Yes or No)	No contact with CORAF	Other contact (specify)

Etc.

Appendix 2. Contact persons by country for biotechnology survey.

Contact person	Country	Institution/address	Phone	E-mail
Dr Roger G. Zangre	Burkina Faso	Charge de recherche, directeur de l'agence nationale de valorisation des résultats de recherche (ANVAR), Center national de la recherche scientifique et Technologique (CNRST), Ouagadougou.	226 61 02 77	rgzangre@fasonet.bf
Jean-Didier Song	Burkina Faso	Université de Ouagadougou UFRS/SVT, 03 BP 7021, Ouagadougou 03	226 33 73 70	zongojd@univ-ouaga.bf
Brehima Diawara	Burkina Faso	CNRST BP 4047, Ouagadougou	226 31 53 21	dta@fasonet.bf
Dr Gnissa Konate	Burkina Faso	Chef du laboratoire de virologie INERA, BP 476, Ouagadougou 01,	226 3192/07/08 (Fax: 226 319206/34 0271)	
Zakariya Yeye	Burkina Faso	SIDWAYA (Press), 01 BP 507 Ouaga 01	226 30 63 07	redaction@fasonet.bf
Simon Zok	Cameroon	RAD Ekona, PMB 25 Buea	237 332 20 22/332 20 23/987 67 18 (cell phone)	Zoksimon@yahoo.com
Prof. Omokolo Ndoumou Denis	Cameroon	BP 47, Yaoundé	237 223 12 15	Domokolo@uycde.uninet.cm
D.A. Mbah	Cameroon	IRAD BP 1452 Yaoundé	237 2224813/2235467	dambah@yahoo.co.uk
J.M. Negate	Cameroon	IRAD BP 2123 Yaoundé	237 223 35 38/222 4813	jmngveve@camnet.cm
Lawrence B. Shang	Cameroon	Tadu Dairy Cooperative Society, PO Kumbo, Bui, NWP.	237 348 1617 Fax: 237 348 1617	
Prof. Vincent Titanji	Cameroon	Biotechnology Unit, Faculty of Science, University of Buea, PO Box 63, Buea, SW Province	237 332 2532	ubuea@uycde.uninet.cm
Mary Fosi Mbantenkhu (Mrs)	Cameroon	Ministry of Environment and Forestry,		
Dr Abdourahmane Sangare	Côte d'Ivoire	Yaounde Centre national de recherche agronomique (CNRA), 01 BP 1740 Abidjan 01	225 23472024/22420366	abous@africaonline.co.ci
Prof. N'Zi Georges Agbo	Côte d'Ivoire	University of Cocody, 22 BP 582 Abidjan	22225 07040741 225 22 44 03 07	agbo_nzi@hotmail.com
Prof. N'Guessan Yao Thomas	Côte d'Ivoire	Ministry of Higher Education and Research, BP V152 Abidjan	225 20 21 36 20	Nguessank@ci.refer.org
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Vincent Kouassi	Côte d'Ivoire	Le National (Press) 16 BP 165 Abidjan 16	(225) 22 52 27 43 /2252 2742	Kavincefr@yahoo.fr
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Eric Okoree	Ghana	Ministry of Environment and Science (MES), PO Box M232, Accra	233 21 666049	Eriokor@yahoo.com
Ransford Tetteh	Ghana	Daily Graphic, PO Box 742, Accra	233 21 228177	mest@africaonline.com.gh ranst59@hotmail.com www.graphicghana.com

Appendix 2. (cont.)

Contact person	Country	Institution/address	Phone	E-mail
R. Harry Reynolds	Ghana	Ghanaian Times, PO Box 2638, Accra	233 21 223285 or 233 21 228282	newtimes@ghana.com www.newtimescorp.com
Affail Monney	Ghana	GBC Radio, PO Box 1633, Accra	233 21 221161	monney123uk@yahoo.co
Dr Richard Akromah	Ghana	Crop Science, KNUST, Kumasi	233 51 60332	crop-ust@africaonline.com.gh
Dr S.K. Dery	Ghana	Coconut Research Program, PO Box 245, Sekondi.	233 31 46366	cocopri@africaonline.com.gh
Dr M. Agyen-Frempong	Ghana	Veterinary Services Dept. PO Box M161, Accra	233 21 775777	vetsdept@africaonline.com.gh
Dr Bennet Lartey	Ghana	CSIR-Plant Genetic Resources Institute, PO Box 7, Bunso	233 27 540124 or 233 81 24124	tblartey@yahoo.com
Raphael F. Fiagbomeh	Ghana	Green Earth Organization(NGO), PO Box AN16641, Accra	233 21 232762	greeneth@ncs.com.gh www.greenearth.org.gh
Abraham Baffoe	Ghana	Friends of the Earth Ghana(NGO), FOE-Ghana, PMB, GPO, Accra	233 21 512311/512312	foeghana@africaonline.com.gh
Dr Elizabeth Acheampong	Ghana	Dept. of Botany, University of Ghana, Legon.		acheampongelizabeth@hotmail.com
Albert Aubyn	Ghana	CSIR-Crops Research Institute, PO Box 3785, Kumasi.	233 51 60389/60391/60425	criggdp@ghana.com
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Dr S.K. Offei	Ghana	Dept. of Crop Science, University of Ghana, Legon	233 21 500629	skoffei@yahoo.com
Dr W.K.A. Amoa-Awua	Ghana	CSIR-Food Research Institute, PO Box M 20, Accra	233 21 500470	mhalmfri@ghana.com
Dr Alamirfinn Touré	Mali	Ministère de l'équipement de l'aménagement du territoire de l'environnement et de l'urbanisme, Coordinateur du Projet d'élaboration de la stratégie nationale de biodiversité, BP 2357, Bamako	223 23 3463 cellulaire: 223 74 13 84	astoure@malinet.ml
Dr Mamadou Niang	Mali	Central Veterinary Laboratory (LCV), Division of Research and Diagnosis, BP 2295, Bamako	223-243344	dglcv@datatech.toolnet.org
Dr Bretaudeau Alhousseini	Mali	IPR/IFRA, BP 06, Koulikoro		bretaudeau@afribone.net.ml
Dr Oumar Niangado	Mali	Syngenta Representative BPE 476, Bamako	223 228 14 78	niangado.o@datatech.toolnet.org

Appendix 2. (cont.)

Contact person	Country	Institution/address	Phone	E-mail
Djibril Koné	Mali	ADAF/Galle (NGO), BP 3267, Bamako.	223 22 00 33	adafgalle@afribone.net.ml
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Appendix 3. ASARECA biotechnology initiative stakeholders year 2002 meeting—further details on outcome.

Workshop on biotechnology and biosafety (see also No. 3 below)—the working group examined the background paper on biotechnology and from that developed a workshop agenda around discussion of the possible priority opportunities. The agenda was shared with key stakeholders such as the ASARECA network directors prior to finalization. The goals of the workshop were to:

- Develop consensus on priorities for regional biotechnology research and technology adaptation or transfer.
 - Establish collaborative relationships with advanced research institutions both international (IARCs, and US and EU universities, private sector) and in the region.
 - Develop a programmatic approach that combines research with training to improve capacity in the region.
 - Identify important but limited short-term training opportunities to strengthen capacity in the region.
 - Develop programmatic strategies for enhancement of public–private sector partnerships in the region.
1. Background papers on biosafety—two background papers were commissioned to provide a basis for a program design in this area by:
 - a) examining current status of biosafety in the region, outlining different options for the goals of a regional biosafety program, and identifying strategic approaches to achieving each of the optional goals
 - b) discussing options for administrative approaches to a regional biosafety systems including issues of:
 - possible organizational structures of regional biosafety system
 - management/administrative systems and facility requirements
 - relationship between regional systems and national regulatory structures
 - technical training needs related to biosafety
 - design of monitoring and evaluation systems.
 2. Workshops on biosafety—following the examination of the two background papers on biosafety per above, the working group designed agendas for two regional workshops. These was shared with key stakeholders, particularly among policy and regulatory officials in the region, prior to finalization, to:
 - a) sensitize stakeholders on the general issues of biosafety and develop a consensus on the specific goals of a regional program on biosafety through discussion of options as outlined in the corresponding background paper
 - b) the second workshop dealing with the structural and administrative specifics necessary to design and implement a regional biosafety system.

The consensus that derives from these two workshops forms the basis for the proposal for a regional biosafety program under ASARECA.

3. Final wrap-up workshop—the working group reviews the outcomes of the biotechnology/biosafety and the second biosafety workshop to determine if any key issues remain unaddressed or require further discussion to finalize the agenda and plan for the follow-on program in biotechnology and biosafety. A final workshop was planned to validate the program priorities and implementation strategies and to cover any remaining issues such as socioeconomic concerns, intellectual property rights, etc.
4. Technical support/oversight of coordinator—external technical support and oversight will be sought to assist the ASARECA secretariat, the coordinator, and the working group. Specifically, the technical support group(s) will oversee the technical content of the work of the coordinator on behalf of the ASARECA secretariat. Functions include:
 - assisting in preparation of agenda, identifying speakers, etc. for working group meetings and workshops
 - reviewing terms of reference for commissioned background papers and review of draft papers before submission to ASARECA secretariat and working group
 - participate at working group meetings and workshops
 - review of summary reports from working group meetings and workshops before submission to ASARECA secretariat and working group
 - input and review in preparation of final proposal.

Budget

A budget of US\$262 000 was drawn for implementing meetings and other work as per above. USAID, through ABSP, committed US\$90 000 for implementing this work.

Timeline

Below the timeframe for implementing the above workplan is provided by quarters:

Sept– Dec 2000

- First meeting of WG (4–8 Sept)—review TOR and prepare detailed work plan.
- Select and hire biotechnology coordinator.
- Prepare TOR for commissioned background papers.
- Commission background papers (biotech and first biosafety).
- Brief ASARECA CD on progress of program planning at (8–10 Nov).

Jan–April 2001

- Second WG meeting—review biotech and first biosafety background papers and develop first workshop agenda.
- Share workshop agenda with key stakeholders (network directors) for comment.
- Biotechnology/biosafety workshop.
- Third WG meeting immediately following workshop to synthesize workshop outcomes.
- Commission second biosafety paper.

May–Aug 2001

- Fourth WG meeting—review second biosafety paper and develop second workshop agenda.
- Second biosafety workshop.
- Fifth WG meeting immediately following workshop to synthesize workshop outcomes.
- Coordinator initiates preparation of biotechnology/biosafety proposal(s).
- Coordinator with review of WG develops agenda for final wrap-up workshop.
- Final workshop to address remaining issues and ensure consensus on proposal(s) priorities and approach.

Sept–Dec 2001

- Coordinator submits draft of proposal(s) to WG for review.
- Sixth and final meeting of WG to finalize proposal(s) and discuss with key stakeholders.
- Coordinator finalizes proposal(s) and submits to ASARECA Secretariat.

Project evolution and workshop recommendations

With the objectives of the planning process/terms of the WG defined that included the commissioning of papers on biotechnology and biosafety, the WG planned the stakeholders meeting for June 2002 in Nairobi. The background paper on biotechnology options for the subregion lists out priority crops and their constraints as well as the technologies available to tackle the constraints, and the two biosafety papers on the current biosafety status of the region with suggestions for the regional biosafety structure were given to the WG to study and to make their views known to the stakeholders meeting. The WG feedback to the consultant's report on biotechnology indicated that:

- it was felt that the scope of the report was too narrow in that it focused mainly on transgenic crops
- it totally ignored livestock
- development of transgenic crop capability was to go hand in hand with the building of capacity for biosafety management.

The WG suggested the following outputs for biotechnology:

- Biotechnology is to address the agricultural needs, opportunities, and constraints available. The activities to be undertaken include:
 - determining needs and constraints
 - establishing virtual centers of excellence on specific constraints
 - developing or adapting biotechnology interventions.
- Efficient dissemination of demand-driven biotechnologies to the public and private sector is to be ensured. There is need to facilitate technology transfer.
- Capacity to integrate biotechnology research and development in the subregion is to be increased.
- Effective planning, monitoring, and evaluation systems should be in operation.

Biosafety

By far the most far-reaching recommendation was the one on biosafety. The consultant's report endorsed by the WG was submitted to the stakeholders' meeting. The components of a biosafety regulation were stated as comprising:

- legislation (national) covering issues such as permission needed, appeals, framework and responsibility, labeling, exclusions, among others
- regulations covering detailed procedures and guidelines.

The model of a National Biosafety Framework was given. This comprised a biosafety administration receiving applications that is serviced by inspectors and sources public input into applications. The administrator sends the application to the Scientific advisory committee that then selects the appropriate reviewers and gives feedback on the results to the administrator, who now sends these results to the national decision making body. The national decision making body receives public reaction to the applications directly. Before there can be a subregional framework, each country must first of all have its review process in place. The biosafety review process is costly, repetitive, and requires special expertise. The expertise needed would come from people of diverse backgrounds such as biologists, ecologists, entomologists, microbiologists, veterinarians, and legal practitioners, among others. The regional framework was considered at various tiers from the national to the subregional and from the subregional to the regional and from the regional to the global. At the national level, the national biosafety focal points link to the subregional support service. These subregional bodies would be four, namely, North Africa Regional Support Service (North Africa RSS), West Africa RSS, the Eastern and Central Africa RSS, and the Southern Africa RSS. These subregional support services would all feed into the African Clearing House. The African Clearing House would then be linked to the Global one, which is the Cartagena Protocol on Biosafety Clearing House. Technical reviews of biosafety could be done at the subregional level. Regional review teams can draw up recommendations to assist national decision-making. The final decision will be at the national level. The role of ASARECA will be to assist member countries establish biosafety frameworks at the national level, while at the subregional level, ASARECA can:

- coordinate regular/general training
- coordinate scientist training
- provide platform for food and feed safety checks on GM-technology
- coordinate subregional biosafety research
- interact with international players
- source funds for projects.

The consultant's report suggested the establishment of a biosafety project within the Biotechnology and Biosafety Program. The purpose of the project is to establish an effective and efficient subregional biosafety framework. The outputs of the proposed biosafety project are:

- Subregional knowledge base to support biosafety decision making established.
The indicators would be training, linkage and partnership, and expedited review.

- Subregional template for conducting reviews established. Indicators are the voluntary adoption of established standards for review of applications. Also biosafety and IPR considerations to be included in all projects proposal identified by the biotechnology working group.

WG discussion

After receiving the reports of the WG in plenary sessions, the stakeholders broke into five discussion groups to deliberate on various components according to the given terms of reference. Part of the first day and the entire second and third days were used for the group discussions and presentation of reports. The terms of reference for group discussions are as indicated below. The Crops and Forestry, Livestock, and Microbiology discussion groups were asked to make recommendations regarding:

- report in priority setting goals for biotechnology initiative
- draft biotechnology framework—outputs, activities, indicators of success, among others
- list of commodity constraints and interventions proposed by the WG
- ASARECA agenda for commodity biotechnology—to shortlist five prioritized commodity constraints and research gaps
- capacity building needs and the available capacity
- possible pilot research projects
- suggestions for effective linkage with stakeholder groups
- suggest next steps.

The Policy, Biosafety, and Intellectual Property discussion group was asked to make recommendations on:

- presentation by consultant on biosafety and outcomes, comment on goals for biosafety activities
- draft biosafety framework
- challenges facing ASARECA member countries on IP and role of ASARECA to address the challenges
- ASARECA agenda for biosafety, IP, and biotechnology policy
- linkage with stakeholder groups.

The last discussion group dealing with Governance and Management of ASARECA Biotechnology and Biosafety Initiative was asked to make recommendations on:

- mechanisms for implementing ASARECA biotechnology and biosafety initiative: institutional arrangements/structures at national and regional level
- management of biotechnology and biosafety initiative: implications for coordination and assistance of secretariat
- strategic alliances with the IARCs, private sector, ARIs, and universities
- governance structure: steering committee, external evaluation and impact assessment
- finance: possible funding sources
- action plan and timetable for implementation.

The outcome of the group discussions were submitted to the WG together with the report of the second biosafety workshop to prepare for the final wrap-up meeting as indicated in the above planning process guideline.